BULLETIN

OF THE

Society for the Promotion of Engineering Education

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EDITORIALS.

The Technische Hochschule at Charlottenburg.—The paper describing this famous technical school in detail was one of the most interesting features of the Boston meeting. It was presented at a joint session of the various sections into which

the latter part of the convention was divided. Dr. Heuter, the author of the paper, is well acquainted by personal contact and close observation with every detail of the university. He has gathered a collection of pictures which supplement the descriptive matter admirably. The members of the Society will appreciate this opportunity to become more familiar with what is probably the best-known technical school in Europe.

The Committee on Statistics.—One function of the BULLETIN is to get committee reports before the membership promptly. A number of such reports are in preparation and will be printed immediately after completion. The first report of the series, that of the Committee on Statistics, is printed in this issue. The Statistics Committee has had a long and honorable career as is evidenced by the list of statistical articles appended to the report. Last year the Committee had no definite task assigned and therefore devoted attention to a study of the place of statistics in the work of the Society. The recommendations will serve to guide the Committee in future work. One of the most important of the suggestions is that the efforts of regularly constituted and liberally supported statistical bodies should be utilized by applying the facts thus gathered to the needs of our Society.

The Highway Engineering Education Papers.—A brief account of the educational session held in connection with the recent American Road Congress was given in the November BULLETIN. The session was held under the chairmanship of Professor F. P. McKibben. The text of the papers presented is given in this number. The educational side of highway engineering is a comparatively new development. In three years great progress has been made so that now all important technical schools give instruction in the subject and in some cases it is made a specialty. The practical highway engineers are interested in the educational side of the work, as is evidenced by the large attendance at the educational session at Atlantic City, and by the close attention given to the speakers. There was no opportunity then for discussion, but there is

now through the BULLETIN. The papers are therefore laid before the membership for this purpose.

More Educational Fundamentals.—Last month Professor Springer outlined his "spherical-want" system and showed us, among other interesting things, how the young robin has an education perfectly adapted to its needs because at each stage of its elementary training the mother bird utilizes a physical want of the pupil. A paper along a somewhat similar line was presented to the Society by Professor V. Karapetoff in 1908. Professor Karapetoff named his plan the "concentric" system, his idea being that each educational "layer" should leave the pupil with a useful knowledge of the subjects studied so that, if he could go no farther, he would not suffer for life through having an incomplete education. A comparison of the two plans with each other and with existing practice will yield helpful suggestions. While all teachers will not agree with either of these writers that our educational system is radically wrong, all will admit the existence of serious faults. It is some comfort to remember, however, that after all it is not the teaching but the teacher that is most important. Just as Mark Hopkins on one end of a log and a boy on the other made a university, so a real engineer, an apt pupil and a live engineering problem make a technical school.

NEW MEMBERS.

By letter ballot, the Council this month elected to membership Messrs. G. A. Gabriel, A. B. Newhall, F. J. Rankin, R. A. Seaton, F. W. Taylor and J. P. Tivey, whose applications are listed on page 60 of the October BULLETIN. Also J. S. Crandell, B. G. Elliott, M. B. Greenough, D. R. Jenkins, S. S. Keller, F. C. Loring and G. W. Smith, whose applications are listed on page 130 of the November BULLETIN. In addition to the above the following were elected on the same ballot:

APPLIN, SAMUEL, Instructor in Iron Working, University of Pennsylvania, Philadelphia, Pa. 1912

BIGGIN, F. C., Professor of Architectural Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1912
BLOEMKER, CHAS. W., Instructor in Forging, University of Pennsylvania, Philadelphia, Pa. 1912
BRINK, R. W., Instructor in Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. 1912
CARLSON, W. W., Assistant Professor of Shop Methods and Practice and Superintendent of Shops, Kansas State Agricultural College, Manhattan, Kans. 1912
CORY, M. M., Instructor in Electrical Engineering, Michigan Agricultural College, E. Lansing, Mich. 1912
DURHAM, EDW. B., Associate Professor of Mining, University of California, Berkeley, Calif. 1912
EDGECOMB, R. E., Instructor in Civil Engineering, Oregon Agricultural College, Corvallis, Ore. 1912
FAWKES, G. W. H., Instructor in Wood Working, University of Pennsylvania, Philadelphia, Pa. 1912
FELGAR, JAS. H., Dean of the College of Engineering, University of Oklahoma, Norman, Okla. 1912
HALL, P. R., Instructor in Iron Working, University of Pennsylvania, Philadelphia, Pa. 1912
HILL, A. E., Professor of Chemistry, New York University, New York, N. Y. 1912
HOLDER, F. J., Professor of Mathematics, University of Pittsburgh, Pittsburgh, Pa. 1912
KREWSON, R. H., Instructor in Iron Working, University of Pennsylvania, Philadelphia, Pa. 1912
LAWLEY, EDW. M., Instructor in Iron Working, University of Pennsylvania, Philadelphia, Pa. 1912
LENDALL, H. N., Instructor in Mathematics and Drawing, Rutgers College, New Brunswick, N. J. 1912
MORGAN, WM. F., Trustee of Columbia University, Arch 11, Brooklyn Bridge, New York, N. Y. 1912
MORRIS, J. J., Professor in Mechanical Constructive Practice, University of Pennsylvania, Philadelphia, Pa. 1912
MOUNCE, J. L., Instructor in Wood Working, University of Pennsylvania, Philadelphia, Pa. 1912
MURPHY, J. F., Instructor in Foundry Work, University of Pennsylvania, Philadelphia, Pa. 1912
STEVENS, A. C., Instructor in Electrical Engineering, Cornell University, Ithaca, N. Y. 1912
THOMPSON, ALFRED, Instructor in Wood Working, University of Pennsylvania, Philadelphia, Pa. 1912
THURSTONE, L. L., Instructor in Descriptive Geometry and Drawing, University of Minnesota, Minneapolis, Minn. 1912

WERNECKE, CHAUNCY, Instructor in Civil Engineering, University of Washington, Seattle, Wash. 1912

SUGGESTIONS FROM THE SECRETARY.

With the bills sent out some weeks ago by the treasurer were enclosed blank forms for names of possible members. As a result a number of names have been received and invitations have been extended in the names of the members who sent in the lists. The Membership Committee needs assistance of this sort in maintaining a healthy growth of the Society membership and appreciates it.

A considerable number of papers from the program of the Boston meeting have now been laid before the membership through the BULLETIN. Written discussion on these is in order. As far as possible these communications will appear at once in the BULLETIN.

You have noted the steady growth in the advertising section of the BULLETIN. The advertising is bringing results to the advertisers and to the Society. If the members will mention the BULLETIN in writing to advertisers the latter will be convinced that their "copy" is read.

The Syllabus of Mathematics is being well received everywhere. The demand for copies continues unabated and will soon exhaust the present edition. It is to be hoped that the copies are not being idly filed on book shelves merely to lend a cheerful air by the bright blue covers but that they are being of real service to young and old alike. Professor Huntington would appreciate suggestions and criticisms regarding the report so that it may be made as perfect as possible.

The next issue of the BULLETIN will be the year-book. As this will not make very lively reading for January the Publication Committee hopes to have the efficiency papers in your hands in bound form quite early in the year. These papers will form Part 1 of Vol. XX of the *Proceedings*. The year-book, however, will be well worth study, as through it one becomes acquainted with changes in work and location of his

friends. By merely reading over the names one renews acquaintance with the membership. The list will comprise nearly 1,200 names, a substantial increase over last year when there were 1,040 members in the Society.

REPORT OF STANDING COMMITTEE ON STATISTICS.

To the present committee the most important question which presented itself, in the absence of formal instructions by the Society, was:

What should be the functions and policy of a committee on statistics? Such time and labor as we have been able to spare have been devoted mainly to this fundamental question, and to it the present report will be devoted.

In studying this question, we have invited suggestions from members of the Society; we have corresponded with officers of the U. S. Bureau of Education, the Carnegie Foundation, and the national engineering societies, as well as with engineering editors; we have reviewed the published proceedings of this society, making a list of statistical articles.

Our invitations to members of the Society elicited no suggestions except from the president, the secretary, and the former chairman of the committee. Responses from other correspondents have also been meager as yet. The list of statistical articles from our *Proceedings* is appended to this report, and may be serviceable for reference.

It may naturally be asked why the present committee had any occasion to question its own reason for existence, rather than merely to follow, so far and so well as it might, the comprehensive program worked out by its predecessors and embodied in the instructive and painstaking reports presented to the Society in certain previous years. Highly as we appreciate the energy, enthusiasm, and industry expressed by those reports, we have not deemed it practicable to attempt to imitate them, nor are we on the whole convinced that it is worth while for a committee of the Society to operate annually upon so ambitious a scale.

The appropriate functions and policy of this committee seem to us to be essentially the following:

1. To exercise any practicable influence on such other collecting agencies as are already in the field, to the end that in dealing with engineering education their questions and material shall be adapted as completely as possible to our needs. Among these agencies, the U. S. Bureau of Education is most important; the Carnegie Foundation, and some of the engineering and scientific journals may deserve consideration. If permitted a voice in determining the direction of their activities, we should naturally afford any assistance we can in execution.

2. To compile each year for the Society a synopsis of statistical material on engineering education that may have been published during the year.

3. To take further initiative and responsibility only in case it should seem important to secure the collection of statistics not otherwise provided for; and

4. To exert, so far as possible, a conservative influence against any projects for statistical investigation, which would impose on the administrative officers of our institutions burdens quite out of proportion to the results obtained.

We are not wholly convinced that these functions really justify the maintenance of a standing committee of the Society. That question, together with the formulation underlying it, we respectfully submit for discussion. As a contribution toward such a discussion we present the following observations:

This Society exists primarily for the purpose of ascertaining and discussing facts and opinions about engineering education. Some of these facts are so well defined and classified as to admit of numerical statement. Thus arise statistics. Simple as this seems, the reputation of statistics is notoriously bad. They are proverbially mendacious. This probably connects itself with the dictum of the distinguished French mathematician, that mathematics is the science which calls different things by the same name. Thus we have tables of

students taking civil engineering, which may include students preparing for mining or forestry, or sanitation, and may exclude others because they happen to be not yet differentiated from a general engineering group. We have statistics of teaching staffs, which do not, and cannot take account of their dividing their time between teaching and professional practice. On such statistics it is easy and inevitable to base false inferences. Essential for statistical work of real value are, therefore, (1) agreement on precise definitions; (2) the framing of questions which shall have the same meaning to all who are expected to answer them—a task of no little difficulty; (3) the securing of completeness of replies; (4) clear and orderly presentation of the results.

It will be sufficiently evident that these conditions are seldom fully met. Whatever may be undertaken by individuals, it would be in our judgment unwise for this Society to give its sanction through a standing committee, or otherwise, to the collection and publication of any statistics which fall below the high standard of quality implied above.

Again, there are particular matters which admit of successful statistical analysis, but do not depend for their interest on annual or periodical repetition. These, also, we believe, may well be left to the initiative of individual members.

It seems to us in conclusion desirable that the question of continuing a standing committee on Statistics be considered as an essential part of the policy of the Society, with reference to committee organization in general, and that if the committee is continued, its functions and policy should be defined by the Society along the lines above recommended or otherwise.

Such consideration seems to us particularly timely in view of the expansion of committee work about to be initiated.

H. W. Tyler,
Walter B. Snow,
Lewis J. Johnson,
Committee.

Notes on Statistical Articles in Proceedings of the Society for the Promotion of Engineering Education.

Vol. I, *page 50:*

Requirements in Mathematics for Engineering Education—A. N. Talbot. Table showing relation between time given to pure mathematics and that devoted to the entire course in twelve engineering schools for the departments of civil and mechanical engineering.

Page 119:

The growth of American Mining Schools and their Relation to the Mining Industry—S. B. Christy.

Table I—total number of graduates from sixteen mining schools in the United States, to 1892.

Table II—number of graduates in civil, mechanical and mining engineering, 1880–1892, compared with total metallic product, total mineral product, etc.

Statistical discussion of normal relative demand for engineers and for mining engineers.

Attendance at American and European mining schools.

Page 184:

The Teaching of Graphical Methods in Engineering Colleges and Schools. Statistical appendix—Prof. H. S. Hele-Shaw.

Vol. II:

Common Requirements for Admission to Engineering Courses—F. O. Marvin. Tabulation of subjects required in seventy-seven colleges.

Occupations of Alumni of Rensselaer Polytechnic Institute between 1883 and 1892—E. Marburg.

Vol. III:

Entrance Requirements for Engineering Colleges, Committee Report (page 25)—Profs. Marvin, Merriman, Flather, J. P. Jackson and Tyler, Comm.

Requirements in one hundred and nine colleges.

Tables in regard to entrance conditions, admission by certificate, changes desired, etc.

Requirements of American Engineering Schools in Non-Professional Studies—L. E. Reber.

Tabulation for thirty-seven institutions.

Graduation Theses and Degrees, with tabulations—Storm Bull.

Vol. IV:

Page 31:

A Quarter Century of Progress in Engineering Education—R. Fletcher. Incidental general statistics.

Vol. V, *page 295:*

The Agricultural College in its Relation to Engineering Education —C. S. Murkland, with statistics by W. S. Aldrich on Attendance in Engineering Courses, Degrees Conferred, etc.

Vol. VI, *page 56:*

Engineering Education in the South—J. J. Wilmore.

Vol. VII, *page 127:*

Electrical Engineering Courses—F. C. Caldwell. Detailed statistical study of curriculum for eighteen institutions; drawing, shop-work and engineering laboratory practice.

Page 176:

Engineering Colleges—H. E. Smith. Tabulation of total hours in mechanical and electrical courses for ten institutions, with charts.

Vol. VIII, *page 11:*

Engineering Education in the United States at the End of the Century—I. O. Baker. General statistics of institutions, students and graduates.

Page 223:

Minor considerations Affecting the Arrangement of a Course of Study in Civil Engineering—H. S. Jacoby. Hours per week, hours of credit, number of subjects per week, and frequency.

Page 256:

Architectural Education—J. M. White. Students, graduates, tuition fees, etc. Statistics of curricula.

Vol. IX, *page 70:*

Modern Languages in Engineering Courses—C. L. Crandall.

Page 330:

Preliminary Report of Committee on Statistics, with suggestion of subjects to be studied:

1. Number of undergraduates, graduates and alumni by years and departments.
2. Number of buildings.
3. Value of equipment.
4. Number of teachers.
5. Floor space required and used per student in drawing-rooms, laboratories and shops.
6. Maximum number of students which could be cared for.
7. Number of students per instructor; by departments.
8. Time assigned to different subjects and distribution.
9. Sources and amounts of revenue.
10. Annual expenditures, classified.
11. Total expenditure, and expenditures per student, in engineering, in arts and sciences, etc.

Vol. X, *page 57:*

Methods of Grading Students—C. P. Matthews.

Page 231:

Second Report of Committee on Statistics; definitions of terms used; table of attendance for one hundred and eighteen institutions, including four foreign; total attendance 16,433; also for enrollment in academic, scientific, normal, agricultural, domestic science, music, art, law, dentistry, medicine, pharmacy and theology departments.

Table 2; distribution of engineering students by departments and classes.

Vol. XI, *page 258:*

Third Report of Committee on Statistics; attendance charts for students enrolled in 1901–2 in certain engineering colleges.

Vol. XII:

Statistical Tabulations (reprinted from Vol. X).

Vol. XIII, *page 14:*

Presidential Address—F. W. McNair. Statistics of mining schools.

Page 205:

Report on Requirements for Graduation. Curriculum statistics—Dean W. G. Raymond, Chairman.

Vol. XIV, *page 94:*

Fourth Report of Committee on Statistics. Tabulation of 2,477 degrees conferred in 1904 by 82 institutions.

Vol. XV, *page 124:*

Relative Efficiency of Instruction in Engineering Subjects—J. M. White. A method of measuring amount of instruction.

Page 201:

Work of Freshman and Sophomore Years—F. A. Fish.

Time for different subjects.

Page 416:

Report on Industrial Education; with incidental statistics—Prof. C. M. Woodward, Chairman.

Page 599:

Examination Data—R. D. Bohannon. Comparison of examination and term records.

Vol. XVI, Membership Statistics.

Page 98:

Proposed Course in General Engineering, with curriculum statistics —Mr. H. Frost.

Page 113:

Mechanical Engineering Curricula—W. T. Magruder.

Statistics for 26 institutions.

Page 136:
Modern Languages; statistics for 46 institutions—Prof. A. S. Wright.
Vol. XVI, *page 307:*
Careers of Graduates in Mechanical Engineering, with charts (Stevens Institute)—Prof. F. DeR. Furman.
Vol. XVII, Membership statistics.
Page 105:
University Extension—L. E. Reber.
Page 179:
Graduates; University of Michigan; Occupations, Salaries, etc.
Vol. XVIII, Report on Degrees—Dean W. F. M. Goss, Chairman.

LETTER TO THE EDITOR.

SECRETARY S. P. E. E.,

Dear Sir: Allow me to mention a subject which, to my present knowledge, has not been given a place among the vital subjects being discussed by our society. I refer to the indexing of scientific and engineering text books. Taking down three standard American texts from my shelf I discover this:

Text No. 1	sixth edition	530 pages	390 items in index.
Text No. 2	third edition	260 p[illegible]	272 items in index.
Text No. 3	second edition	885 [illegible]	1,560 items in index.

Number three has almost two items per page and is in favor with students. But look at the ratio of pages to items in the case of No. 1 and of No. 2. Does one care to believe that for every 1.4 pages of a standard text from the pen of a noted teacher in one of our leading colleges there is contained only one item of importance! And must all items be recorded under one heading only, and never be allowed more than one line? Compare the above with two European texts which I select simply because they are at hand:

Text No. 4	480 pages	1,220 items.
Text No. 5	305 pages	2,160 items.

Let me say here that the authors of Nos. 1 and 2, or of No. 3, would dislike having the material of their texts classed below that of the authors of Nos. 4 and 5. When are we going to get around to the "scientific management" of indexing?

An interesting little volume of the Home University Library series that lies before me (and which cost me the impoverishing sum of five nickels) has an index of six hundred items for its 250 small pages. And it belongs to popular literature! Someone has said that the value of a book depends upon its index. I could grow eloquent upon the subject of the efficiency of hunting through a text for what can not be found. However, I'd rather peruse a paper by some one else on "The Construction and *Use* of an Index to a Book."

Respectfully yours,
ROBERTSON MATTHEWS.

PERSONAL NOTES.

Professor G. G. Hitchcock, of Pomona College, California, is on leave of absence for the year, and will spend part of the time at Cornell University. His address will be 211 Eddy St., Ithaca, N. Y.

Mr. M. W. Pullen, formerly graduate student at Massachusetts Institute of Technology, is now assistant in applied electricity at Johns Hopkins University, where his address is 2110 Calvert St., Baltimore, Md.

Mr. J. J. Richey, formerly instructor in civil engineering at the University of Illinois, has been appointed associate professor of civil engineering, Agricultural and Mechanical College of Texas, College Sta., Texas.

The address of Mr. M. R. Bowerman is changed from Hillsdale, Mich., to 620 Bluemont Ave., Manhattan, Kansas.

Professor Adolph Shane, formerly of Iowa State College, is now dean of engineering at Hyland Park College.

Mr. Sanford E. Thompson, consulting engineer, with main offices and laboratory at Newton Highlands, Mass., has opened a branch office at 141 Milk St., Boston, Mass.

Professor A. F. Nesbit, until recently professor of physics, New Hampshire College, is now electrical engineer in the department of industrial research, University of Pittsburgh. Professor Nesbit is on the staff in charge of the smoke investigation which is being carried on by the University.

PUBLICATIONS RECEIVED.

A Testimony concerning Scientific Management, by Hollis Godfrey, consulting engineer. A reprint from the government report of the hearings on "The Taylor and Other Systems of Shop Management." The testimony was given before a special committee of the House of Representatives.

Bulletins Nos. 18–20 of the United States Bureau of Education. Bulletin No. 18, Teaching Language through Agriculture and Domestic Science, by Prof. M. A. Leiper, of the Western Kentucky State Normal School. Intended as a practical aid to the teachers in rural schools. Bulletin No. 19, Professional Distribution of College and University Graduates, by Bailey B. Burritt. A comparison, with numerous charts and tables, of the professions chosen by graduates of a large number of colleges in the United States. Bulletin No. 20, The Readjustment of a Rural High School to the Needs of the Community, by H. A. Brown. The Bulletin describes the changes made in the courses of study at Colebrook Academy in an attempt to use studies based on the industries and activities of the community for their educational value.

Style-Book of the Columbus, Ohio, Trade School, a Prospectus and Review of work of the department of printing.

Bulletin of the American School of Correspondence. Series 4, No. 2, Self Help.

Bulletin No. 60 of the University of Illinois. The Coking of Coal at Low Temperatures, by S. W. Parr and H. L. Olin.

HIGHWAY ENGINEERING IN A GENERAL COURSE IN CIVIL ENGINEERING.*

BY HUGH MILLER,

Professor of Civil Engineering, Clarkson School of Technology.

In discussing this subject before such an assemblage as this, it might be well to state at the outset that we teachers of engineering cannot hope to teach practical road-building, the knowledge of which must be gained by actual experience; but we can give instruction in all the scientific subjects, now known, upon which good construction of roads and pavements depends. In what follows, therefore, I will indicate what I consider to be the most important of these subjects, and try to show how they may be taken up, to some extent at least, even in a general course in civil engineering. I will not consider, however, those subjects which, while important for the future highway engineer, are now allotted as much time as can be wisely given to them in a well-balanced four year course in civil engineering. Among these may be mentioned hydraulics, drainage, cement testing, etc.

There is no question but that the best training in highway engineering can be given in a postgraduate course after the completion of a general course in civil engineering. Unfortunately, however, all students of highway engineering cannot afford the time or the expense required by such a course, even when arranged as advantageously as the course at Columbia, that is, four winter months, December to March, each year for two years. It seems to me, therefore, that our general courses in civil engineering should in some way be brought into harmony with the growing demand for highway engineers, so

* A paper presented at the sectional meeting of the Society for the Promotion of Engineering Education held in connection with the American Road Congress at Atlantic City, October 3, 1912.

that the graduate in civil engineering will be better fitted than at present to take up responsible work in road-building. The object I have in view is to point out briefly how these changes might be made, believing that if made they would result in better efficiency in the highway engineering staffs and consequently in better and more economical building of highways.

In dealing with the subject from this standpoint, I do not wish to be understood as advocating undergraduate specialization, for, on the other hand, I believe that the entire course of four years in civil engineering should be filled with the required work, taken in common by all candidates for the Bachelor's Degree, excepting perhaps five or six semester hours in the senior year which may be devoted to thesis or to elective subjects. I do believe, however, and this, as I understand it, is one of the objects of this session, that those in charge of our courses in civil engineering should recognize the increased importance of highway engineering, and gradually modify existing courses and insert new ones, so that graduates in civil engineering will be better equipped for highway work.

Local conditions such as the size and wealth of the institution, the size and personnel of its faculty, its laboratory facilities, its existing courses and traditions and other factors, may greatly affect the applicability of the following suggestions, but they are offered here to point out what might be done under favorable circumstances to promote education in highway engineering through changes in the existing undergraduate civil engineering courses.

These suggestive changes are as follows:

1. To adapt one of the elementary courses in surveying to road and street surveying, requiring profiles, cross-sections, earthwork computations and estimates of cost.

2. To add a short field course in geology equivalent to one semester hour, or better, a trip of one week to a region of varied geological formation. (This is in addition to the usual lecture or class-room course in geology.)

3. To include in the course in testing materials, the testing of such road materials as stone, brick, asphalt and the bitumens.

4. To take up the economic problems involved in highway construction in one of the courses in economics.

5. To give more attention to the design of culverts in the courses in masonry or reinforced concrete.

6. To take up the study of specifications for roads and pavements in the course in specifications.

7. To give more time to the design of highway bridges in the courses in roofs and bridges and structural design.

8. And finally, to give over at least two semester hours in the senior year to a course in highway engineering or roads and pavements, as it is commonly called. (At present the average time devoted to this subject is less than one semester hour.)

Four out of eight of these suggested changes have already been carried out wholly or in part at the Clarkson School of Technology, and we hope that several others may be effected in the near future. This, I believe, is taking a more advanced position than other institutions have yet taken, but I believe that the changes are justified and that this opinion will ultimately prevail. It is believed that these changes, if carried out, will result in raising the average efficiency of our highway engineers, and thus accomplish what all advocates of good roads desire, namely, better roads at less cost.

WHAT SHOULD CONSTITUTE A COURSE IN HIGHWAY ENGINEERING.*

BY E. B. McCORMICK,

Professor of Experimental Engineering, Kansas State Agricultural College.

While the work of the highway engineer is highly specialized, the foundation upon which this special training is to be built is, in my opinion, almost identical with that required in any branch of civil engineering. There is, at times, apparently a demand for men, who are competent immediately upon graduation to step into positions in charge of highway work. I do not consider it the province of an engineering school to fill this demand any more than to fill the occasional demands for men to step into superintendents positions in factories or in power plants. We do not expect our mechanical, electrical, or civil engineers to step into positions of authority immediately upon graduation, nor should we expect men to step into corresponding highway engineering positions.

I am a believer in the method of offering options in the senior year of engineering courses. If it is the desire to offer special training in highway engineering, I believe it should be given as an option in the senior year of the regular civil engineering courses, and should be substituted for a portion of the work in hydraulics and in railway engineering. A series of experiments on road materials can very properly be introduced into any strength of materials laboratory course. The same is true for exercises in the study of draft and traction.

The principal engineering work that is required in highway

* A paper presented at the sectional meeting of the Society for the Promotion of Engineering Education held in connection with the American Road Congress at Atlantic City, October 3, 1912.

work is in the design and construction of bridges, and, considering the preparation of a student, it is not likely that any better method of giving that work can be found than is available in the present courses in foundations, structural engineering, bridge design, etc.

As highway engineering is a specialty, preparation in the technical details peculiar to this work should be acquired after graduation, and to some extent between the junior and senior years, or even between the sophomore and junior years. It is my belief that this training can best be secured by a system similar to the special apprenticeships offered by many concerns to graduates in mechanical and electrical engineering, and by many railroads to graduates of the civil engineering course, who wish to follow railway engineering. By cooperation between the engineering schools and the government and state highway departments, a limited number of graduates could, each year, be placed in subordinate engineering positions or apprenticeships where they could receive such additional training as would fit them in the course of a couple of years to take responsible places with highway departments, as county engineers, as contractors, or contractor's engineers.

The number that could be so placed is, of course, limited, but I believe that the number of highway engineers for which there will be a demand each year is limited, and if the variation of the school course from the regular course in civil engineering is slight, there is no reason why the graduates in excess of those for whom places can be found in the special apprenticeships cannot turn to other branches of civil engineering.

If the attempt should be made to turn out finished highway engineers in the time now devoted to the civil engineering course, a few experts in highway construction might result, but their training would, of necessity, be so narrow that failing to secure a job in highway engineering they would not be able to turn to other branches of civil engineering.

I do not consider that a college is any more justified in turning out a highway specialist from a civil engineering

course, than it would be in turning out a specialist in refrigeration from a course in mechanical engineering.

The following outline shows, in the left hand column, subjects now appearing in the senior year of the civil engineering course at the Kansas State Agricultural College, and in the right hand column the modifications that we consider it desirable to make in order to offer an option in highway engineering.

Fall Term.	*Fall Term.*
Bridge Stresses 4(4–0).	Bridge Stresses 4(4–0).
Steam and Gas Engr. C 4(3–2).	Steam and Gas Engr. C 4(3–2).
Drainage and Irrig. Engr. 4(4–0).	Drainage and Irrig. Engr. 4(4–0).
Civil Engr. Dwg. II 3(0–6).	Civil Engr. Dwg. II 3(0–6).
Hydraulic Motors 3(2–2).	Highway Engr. I 3(3–0).
Winter Term.	*Winter Term.*
Structural Design 6(3–6).	Structural Design 6(3–6).
Railway Engr. I 3(3–0).	Railway Engr. I 3(3–0).
Spherical Trig. and Astron. 3(3–0).	Highway Engr. II 3(3–0).
Masonry and Concrete 4(3–2).	Masonry and Concrete 6(3–6).
Surveying V 2(2–0).	
Spring Term.	*Spring Term.*
Elect. Engr. C 4(3–2).	Elect. Engr. C 4(3–2).
Railway Engr. II 4(0–8).	Highway Engr. III 4(0–8).
Geodesy 4(2–4).	Spherical Trig. and Astron. 3(3–0).
Highway Engr. 2(2–0).	Highway Materials Lab. 3(0–6).
Thesis 4(–).	Thesis 4(–).

In this discussion I have not considered the question of the graduate course in highway engineering, as I believe that the necessary advanced technical work can be given better, or at least fully as well, in connection with one of the special apprenticeships.

In a few cases I believe it would be possible to make a combination of the special apprenticeship and the graduate course; for instance, where the state highway department is located at a state school.

ESSENTIAL REQUISITES IN THE MAKING OF A HIGHWAY ENGINEER.*

BY STUART A. STEPHENSON, JR.,

Instructor in Civil Engineering, Rutgers College.

At the suggestion of and in conjunction with Professor A. A. Titsworth, the head of our department of civil engineering, the writer has prepared the following brief sketch as an introduction to the subject-matter of this symposium.

PRESENT PRACTICE.

The course at Rutgers College in highway engineering is practically a new one and, as yet, in process of development. It has been largely a lecture course because, while there are good books on highway engineering, no suitable text-book has been found to meet our purposes.

A book has come out this year, however, which we shall adopt as a text in the classroom for the present ("A Handbook for Highway Engineers," by Messrs. Harger and Bonney, McGraw-Hill Book Co.). Supplementing the lectures, there have been problems in the classroom, draughting-room exercises, visits to locations where road construction is in progress, distribution of government and other pamphlets, and lectures by engineers in actual practice.

POLICY.

The time is not sufficient nor the students prepared for specialization in highway engineering education. This branch of engineering has its place along with other branches. The

* A paper presented at the sectional meeting of the Society for the Promotion of Engineering Education, held in connection with the American Road Congress at Atlantic City, October 3, 1912.

purpose is to teach the fundamental principles of highway construction which includes city streets. What constitutes a proper foundation and how it should be prepared, proper surfacing, gradient and alignment, proper drainage and the disposition of the run-off, proper gutters and sidewalks. Some of the economical advantages of a good road surface are explained as is also the manner of locating new roads. More special laboratory work is contemplated, but it is now carried on principally in connection with other courses.

The policy of the college is to acquaint the student with those general principles that govern the designing and construction of roads and pavements, without specialization in particular methods or materials of construction.

In presenting this paper to-day, the writer comes before you not as the pedagogue or the academician but as the engineer-teacher, bringing to the task an intimate acquaintance of fifteen years in connection with highway as well as other branches of engineering and construction. He advances no theories, for the recommendations herein made were not only an integral part of his own technical training but have been substantiated by mature conclusions born of subsequent experience.

1. The education of the highway engineer should be professional rather than vocational or industrial.

2. It should be part of a liberal course in civil engineering, not a narrow and limited specialization.

3. Previous training.

Granted that the character of the course is to be professional, it is inadvisable to suggest any specialized preparation for a training requiring a broad and deep foundation. A few essentials, however, should be mentioned. Elementary mathematics, a thorough working knowledge of the English language, United States history, geography, elementary physics and chemistry and elementary drawing. One of the classics, preferably Latin, and one modern language, either French or German, should be taken, also some simple form of manual training such as carpentry will prove of great practical value.

4. Professional education.

The subjects included in the general training should be higher mathematics including the calculus, mechanical drawing, geology, both structural and dynamic, crystallography, laboratory physics and analytical chemistry, English language and literature, including composition, rhetoric and public speaking, French, German, political economy, English and European history.

Those subjects of specialized bearing are plane surveying, principles of highway and railroad location and construction, analytic mechanics and hydraulics, masonry design and construction, mechanics of materials, and roofs and bridges. Materials of construction should be carefully studied, that is, road-making materials such as trap-rock, granite, limestone, sandstone, bituminous binders and dust preventatives, concrete, brick, wood and gravel. A short time could be profitably spent on the elements of electrical and mechanical engineering, with especial reference to the construction and operation of modern road machinery.

5. College laboratory training.

Strength of materials will be found of primary importance, such as that of cement, brick, concrete and structural steel. Likewise an investigation should be made of the characteristic properties of the many bituminous road-making materials now being used, to ascertain their relative merits and defects. The wearing qualities of these materials and their ability to withstand climatic influences should also be carefully determined. Some laboratory practice in hydraulics will be found helpful, though it is not necessarily essential.

6. Practical experience during the college course.

The student should be required, during the summer vacations, to take field work in general surveying followed by field practice in railroad location and methods of construction, which not only includes but goes beyond the specific requirements of highway engineering.

The present practice of many technical schools is to be highly commended and should be included as a part of the

work now being outlined, that is, to take the students, during the college term, on tours of inspection of large and representative engineering works, either completed or under construction, not only highway construction, but to show typical examples of masonry and concrete construction, structural steel bridge work, dams, water-works, sewage-disposal plants, tunnels, railroads and other similar structures; in a word, the student should be given a comprehensive view of the entire field covered by civil engineering.

It is hardly necessary to emphasize the fact that the student contemplating the adoption of highway engineering as his life-work should give especial attention, during his undergraduate course, to representative examples of highway and railroad construction, which are very closely associated in their fundamental details.

7. Subsequent experience.

Once out of college, the highway engineer should turn his attention to the specialized aspects of his profession. One, or more if possible, of the representative technical journals should be used as a medium for keeping in touch with the most recent developments relating to this particular branch of engineering or to kindred subjects. He should ever remain the active student and the conscientious investigator, and, in the pursuance of his work, should be a wide reader, consulting the best authorities upon the various topics of allied interest, so as to acquaint himself with accredited methods in each phase of his calling.

Extensive travel, involving an intelligent study of methods and practices at home and abroad, constitutes a most valuable part of a liberal education, and of a kind that can never be obtained within the four walls of a technical school. Under the broader applications of a comprehensive training, the laws governing the construction of roads by the Federal Government and in the different states of the Union should be carefully studied so as to bring about such a uniformity of practice and a coöperation of effort as shall promote the extension

of our national highways and the expansion of our industrial life.

And there is also a political side to the situation, which should be approached with some caution. The construction of roads in this country may properly be said to come under four general classes of governmental supervision, namely, federal, state, county and township or municipal. Granted, as a matter of fact which admits of very little dispute, that each municipality should build and maintain the roads and pavements within its own borders, we have outside those limits the greater problem in the construction and maintenance of the vast avenues of commerce that stretch between our towns and cities.

What department of government is best fitted to supervise this work? Is it the federal authority, the state, or the county? And what is the most equitable and efficient method of taxation for the construction and up-keep of such roads? It is for highway engineers to study these questions from every viewpoint and give to the public what appears to be the best solution.

In passing, the writer wishes to mention that reprehensible practice still surviving in some of our eastern states and known as " working out " the county road tax. In the fall of the year, after the crops have been harvested and there is nothing else to do, the farmers foregather and expend a few desultory efforts on a phase of their welfare that should be considered of primary importance.

At its best, such an attempt is nothing more than a cross between a " watermelon-cut " and a " cider-spree," and at its worst is a cause for shame and reproach in any civilized country or community. These same apparently shrewd and industrious men consider it a better investment to have a truck-load of produce mired hub-deep on a country road in the spring, than to expend a reasonable amount of money in a systematic scheme for highway repair.

It may not be amiss at this time to emphasize a few lessons from the past, to consider present needs and get a glimpse of

the future. Both in city pavements and country roads, many causes of failure have been due to foundations of improper material and defective workmanship; while on the latter roads, obstructed ditches, causing insufficient drainage, together with small culverts and poorly built bridges, have often resulted in great, unnecessary expense and suspended traffic for long periods.

The writer's experience in tropical countries, where the erosive action of violent rainstorms is in many respects more destructive than that of frost in northern climates, has impressed upon him very forcibly the supreme importance of proper maintenance. And in view of these existing conditions, it is not far wide of the mark to say that this very problem of adequate maintenance constitutes one of the most necessary lessons that the American highway engineer has yet to learn. In connection with the maintenance of city pavements, especially, the writer feels called upon to emphasize the need of thorough and systematic methods of street-cleaning, which shall produce proper sanitary conditions without undue annoyance to the traveling public.

What lines of investigation are directing our attention to the task of the future? The more detailed study and determination of the characteristic properties of bituminous and other materials of a similar nature will go a long way toward providing country districts with roads that are both economical and satisfactory. Further experimentation with the absorbent properties of semi-vitrified paving materials, in place of the freezing process as a test of their ability to resist the action of frost, is a matter well worthy of our consideration.

If the wonderful discoveries of science, as presented at the International Congress of Applied Chemistry recently held in New York, will actually give to the world a synthetic rubber at a low cost, then the highway engineer has within his grasp the possibility of the ideal pavement.

Above all, the highway engineer should be a man of wide mental horizon and broad human sympathies. He must stand ready to hold to his convictions like grim death if there is a fun-

damental principle involved and, withal, must be willing to relinquish, at a moment's notice, his most cherished theories when modern research and experience have proved them fallacious.

As the steam roads and suburban electric roads of our country increase in size and importance, so must our highways ever fill a supplementary place of equal importance, in this day of heavy trucking and high-speed automobile traffic. What the capillary system of the body is to the human circulation, so must the highway always be the vital connecting links between the ebb and flow of our modern railroad systems.

To the trained engineer must we look for leadership in this great movement, and may it be the constant aim and ambition of our technical schools to send out men who shall be able, in the near future, to give to the world such examples of the combined art and science of road-building as have been the pride and joy of the British Isles and of many European countries for a hundred years past.

HIGHWAY ENGINEERING EDUCATION.*

BY ARTHUR H. BLANCHARD,

Professor of Highway Engineering, Columbia University, New York City.

The educational training of the engineer who may enter that branch of civil engineering devoted to the economics, construction and maintenance of highways should be considered from two standpoints: first, the essentials, which, from an educational point of view, are considered as prerequisite to a successful career in highway engineering; and, second, practical methods of securing this training under American conditions.

The American youth who has expressed the desire to enter the profession of engineering has various channels open to him. The usual course followed is to enroll in one of the four-year engineering courses designated as civil engineering, mechanical engineering, electrical engineering, chemical engineering or mining engineering. There are, however, notable deviations. Several institutions and some engineers advocate a broader training for the engineering profession than is possible in the ordinary four-year course, and in fact believe that the profession of engineering demands the same type of training as is now universally recognized as desirable for men entering the legal or medical profession.

Usually the American boy, in entering on a technical career, has not fully made up his mind as to the particular field in which he is most interested. In the four-year courses he has in some cases one, and in others two years in which to make up his mind as to which of the five general branches of engineering referred to above he wishes to enter. It is self-evident

* A paper presented before the American Road Congress at Atlantic City on October 3, 1912, and prepared at the request of Wm. T. Mcgruder, president of the Society.

that the ideal training is one which will prepare a student upon graduation to enter any one of the numerous fields of engineering. At least it is possible that a comparatively wide field of activities will be open to a man whichever one of the above courses he takes in the technical school.

Having these general facts in mind, attention will now be riveted upon the situation which confronts the young man who may be one of our future highway engineers. Let us suppose, for example, that he has decided to devote four years to securing a technical education and that there is offered to him the four-year course in civil engineering and a four-year course designated as highway engineering. Which course should he take? The evils of over-specialization in the undergraduate engineering course have been fully discussed in the Society for the Promotion of Engineering Education. Suffice it to say in this discussion before the general public interested in highway improvement that the graduate of the civil engineering course on the one hand has before him a large field of activities for all of which he is equally well equipped. For instance, he may enter the field of structural engineering, sanitary engineering, railroad engineering, geodetic engineering, hydraulic engineering, highway engineering, irrigation engineering and in many cases mechanical, electrical and mining engineering. On the other hand a graduate from a so-called four-years course in highway engineering has, if the course is made up of the subjects which the title implies, only a limited field in which he considers that he is particularly proficient.

The consensus of opinion of eminent highway engineers and educators is to the effect that the highway engineer of the future requires the broad foundation which the four-year course in civil engineering gives. A knowledge of practically all of the subjects included is found of value in the manifold duties imposed in the various positions which he may occupy in the service of municipalities, states, counties, towns, estates, contractors' organizations, consulting engineers' offices, and manufacturing companies.

In the consideration of the training received and the subjects covered in the four-year course in civil engineering relating especially to highway engineering, it is of interest to note the present status of highway engineering in the civil engineering courses of American universities and technical institutions. An examination of the latest catalogues received from ninety-two institutions in the United States offering courses in civil engineering showed that seventy-eight included a text-book-lecture course in highway engineering in the curriculum. The number of recitation-lecture hours in the various courses may be arranged approximately in the following groups: thirteen, 15 hours or less; twenty-eight, 30 hours; seventeen, 45 hours; six, 60 hours; six, 75 hours; three, 90 hours; three, 120 hours; one, 135 hours; and one, 165 hours. Fifteen give some instruction in laboratory work while ten include special courses in highway surveying. In the case of institutions devoting over ninety hours to highway engineering, the general civil engineering course covers three years, while a highway option is taken in the fourth year. A comparison of the present status of highway engineering education as outlined above with the conditions described by Logan Waller Page in his valuable paper on "Highway Engineering," presented before the Society for the Promotion of Engineering Education in 1909, is certainly encouraging, especially when it is remembered that only three years have elapsed. In 1909, according to Mr. Page, fifty per cent. of the institutions investigated did not include a course on highways in the civil engineering curriculum, while it is noted that of the courses in ninety-two institutions examined by the speaker, eighty-five per cent. now give a course in highway engineering.

The importance of the subject of the economics, construction and maintenance of roads and pavements in the United States at the present time demands that more prominence should be given to the course in highway engineering in civil engineering curricula. Having in mind the various component parts which go to make up the curricula, it apppears that

a well-balanced civil engineering course under present conditions should contain a three-hour course of one year in length devoted to highway engineering.

In such a course lectures and text-book work should cover the following topics: historical review of the construction of roads and pavements; preliminary investigations incident to construction; principles of surveying and mapping peculiar to highway work; design of highways; drainage and foundations; construction and maintenance of earth, sand clay, gravel and broken stone roads, including a consideration of the materials which enter into their construction; general consideration of bituminous materials as such and their use in the construction of bituminous surfaces, and bituminous macadam, bituminous concrete, sheet asphalt and asphalt block pavements; the construction and maintenance of wood block, stone block, brick and cement concrete pavements; dust prevention, street cleaning and snow removal; construction of car tracks and pipe systems; comparison of roads and pavements; construction of sidewalks, bridges and culverts; and a general treatment of economics, highway administration and highway legislation.

Laboratory work should be limited to what is sometimes called lecture demonstration work by the officers of instruction. In other words, although it is advisable that the methods of testing all kinds of bituminous and non-bituminous road materials should be brought to the attention of students in civil engineering by actual demonstrations in the laboratory or lecture room, it is not considered advisable to devote the time necessary for each student to run through complete tests as is done by students in the laboratories devoted to the testing of structural materials. In two to five afternoons all the fundamental tests employed in the examination of bituminous and non-bituminous road materials could be demonstrated before a group of from twenty-five to thirty men if the laboratory equipment was properly arranged and the work well planned out. Two to three afternoons would suffice if the testing of bituminous materials were covered in a course given by

the department of chemistry. Unfortunately at the present time very few instructors in chemistry are familiar with bituminous materials, hence the methods of testing will have to be worked up by civil engineering instructors. Eventually some of the time now given by the department of chemistry to carbon compounds or quantitative analysis in courses for civil engineering students can be profitably devoted to the chemistry of bituminous materials.

A limited number of inspection trips covering the economics of highway location, and the construction and maintenance of various types of roads and pavements will be of value.

The time devoted to road or street surveys in some institutions, in addition to the regular work in railroad surveying and general surveying, is of questionable merit. Although there are many problems in highway surveying which are different from those encountered in other branches of surveying, it is doubtful if it is necessary or expedient to use up valuable time on this work considering the number of subjects which it is necessary to include in a broad course in civil engineering. The speaker's experience with civil engineering graduates who have worked under him on highway work has led to the belief that a graduate in civil engineering, who has had a good course in railroad surveying and in railroad curves, together with a comprehensive course in highway engineering as outlined above, is admirably equipped to occupy the minor positions in a field party on highway surveys. In these positions he may acquire, either through advanced study or special instruction, the information and practice necessary to occupy the position of chief of party and the higher positions in the highway department connected with the bureau of surveys. It is, however, advisable in certain instances, where practicable, to divide the time devoted to railroad surveying so that a highway survey outside built-up districts may be added to the course together with the preparation of plans, cross-sections and estimates.

In further consideration of the special training which will

be of benefit to those entering the field of highway engineering, the educational plans which have been evolved to elevate the profession and to equip men thoroughly for this field of engineering work, foreign practice will be given consideration first.

Great Britain affords an illustration of one method by which well trained highway engineers may, under favorable circumstances, be secured. Fortunately for the British engineer his position in highway work is much more permanent than in the United States. There are several reasons why such is the case. Among others may be mentioned the recognition by the British public that the principle of continuity in office of capable engineers results generally in economical and efficacious construction and maintenance of public works. Those American engineers who visited Great Britain at the time of the Brussels International Road Congress in 1910 will, without doubt, find the majority of the prominent highway engineers of England occupying the same positions or higher positions when they attend the Third International Road Congress to be held in London in 1913. This is not a long period but could the same observation be made in regard to the personnel of many of our great state highway departments for a similar period? It should be stated, however, that the subordinate positions in the United States being, in many cases, under civil service regulation are more permanent than those effected by political exigencies. This condition of permanency of position of high officials in Great Britain means that it is possible for young men who are attracted to highway engineering to enter the department of some county or municipal engineer, and, proving capable, to acquire a valuable experience under the continued leadership of an able engineer. In this position a young man of the right caliber may, by hard work, including a large amount of home study, equip himself for the highest positions in highway work in Great Britain. Another safeguard of the British engineer, and an incentive to highway engineers in embryo, is the admirable practice which has been adopted in many cases requiring that applicants for a certain

class of positions shall hold certain grades of membership in the Society of Municipal and County Engineers and in other cases certain grades of membership in the Institution of Civil Engineers of Great Britain.

France offers an entirely different type of training for men who are going to enter the field of highway engineering. All the important positions in this branch of the public service are occupied by picked men especially educated and trained for the service. After a preliminary general education covering as a final period that comparable with the four years high school training in this country, men of high standing are admitted to the Ecole Polytechnique, the course in which is practically two years in length. Upon graduation from this school, the men of high standing are allowed to select one of the several national schools, provided openings exist, in which they will secure special training for the public service in a given field. Those who enter the Ecole Nationale des Ponts et Chaussees devote three years to a general course in civil engineering under the leadership of engineers of the highest grade in the Department des Ponts et Chaussees de France. During the vacations these men are alloted to service on the construction of roads and bridges in various parts of France. It is evident that the training thus obtained is admirable and that the personnel of the engineering staff of the department of roads and bridges of France is exceptionally high.

In America, while in some cases an attempt has been made to give as special instruction in highway engineering a four years undergraduate course in this subject, this method has not given particular satisfaction for the reasons previously noted. Excellent work has been done by many universities in several parts of the country in giving extension courses to groups of men interested in various phases of highway improvement. Very little advanced work, however, has been done through the medium of the American university. The United States Office of Public Roads has evolved a scheme by which men may secure a certain amount of advanced instruction and training in that part of highway engineering dealing

with highways outside of built-up districts. This plan is to place the student engineers in the charge of men in the service of the office in various parts of the country on different kinds of highway work. When it is impossible to work in the field, the men do a certain amount of office work at Washington, receiving instruction by means of lectures on certain phases of highway engineering and also do laboratory work on the testing of both bituminous and non-bituminous road materials.

In 1911, through the generosity of Charles Henry Davis, president of the National Highways Association, there was founded at Columbia University a graduate course in highway engineering. The object in founding this course was to elevate this branch of the engineering profession and to provide an opportunity for men engaged in highway work to obtain advanced instruction and training in the various phases of highway engineering under the most favorable conditions. For many reasons it is fortunate that the first course of this character should be found at a university presided over by a president and trustees who look upon the work of the university from an exceptionally liberal standpoint. While maintaining the high character of all degrees conferred, nevertheless these men believe in opening the courses of instruction to any mature man provided he has the prerequisites for any given course and earnestly seeks information. Likewise it is fortunate that the administrative authorities allow the introduction of an innovation as far as the period of attendance is concerned inasmuch as the graduate course referred to is given in the period from December 1 to April 1. An engineer, therefore, who desires to take all the graduate courses in highway engineering and allied subjects which fulfill the requirements for the Master's degree will necessarily be in attendance for two winter periods, the equivalent of one collegiate year. The selection of this period in which to give this instruction was based upon the prevailing idea among leading highway engineers that it would be feasible for many men to obtain a four months leave of absence during the dull period of the year. This prediction has been found to be correct.

As this plan is somewhat of an innovation in engineering education, it may be of interest to cite certain facts in connection with the attendance during the winter period of 1911–12, which was the first period under this plan. Although the graduate courses were not brought to the attention of engineers until November 1911, there were in attendance fifteen men affiliated with highway work, thirteen of whom registered as candidates for the Master's degree. It is of interest to note that this group included men connected with state highway departments, contractors' organizations, municipal departments, engineering-sales departments of manufacturing companies, county highway departments and consulting engineers' offices. The experience of these men ranged from one to twelve years. They came from widely distributed localities, Connecticut, Massachusetts, New York, Pennsylvania, Maryland, North Carolina, Alabama, Panama and British Columbia being represented.

The curriculum of the graduate work in highway engineering comprises advanced courses in the economics and design of roads and pavements, including a thorough discussion of bituminous surfaces and bituminous pavements; highway bridges and culverts; mechanical appliances used in highway engineering; road and street surveying and highway design; highway laws and systems of administration; management engineering; bituminous and non-bituminous road material laboratory courses; seminars in highway engineering literature; chemistry of bituminous materials; engineering geology; optical mineralogy; and inspection trips covering various types of roads and pavements and manufacturing plants producing highway materials.

A large staff of non-resident lecturers in highway engineering, which includes many of the most prominent highway engineers and chemists in the United States, is employed to give instruction on specified subjects forming an integral part of the various courses. It was decided to throw these special lectures open to the engineering public and to hold the same during evening sessions in order that this feature of the work

may be of maximum benefit to all that may find the university accessible. An attendance of from fifty to one hundred engineers at many of the lectures during the past winter period showed the interest taken in the many problems of highway engineering presented.

During the 1912–1913 winter period a special arrangement will be introduced which is considered of particular interest to practicing highway and chemical engineers. Many, who cannot secure a four months leave of absence, have expressed the desire to devote from six to seven weeks at Columbia University in securing information relative to the manufacture and testing of all kinds of bituminous materials and their use in the construction and maintenance of bituminous surfaces and bituminous pavements. Arrangements have, therefore, been made so that courses covering the above subjects may be taken either independently or as an integral part of the unified graduate course in highway engineering. During a continuous period of about six weeks, beginning in the latter part of December and ending during the first week of February, three courses will be offered as follows. Two weeks will be devoted to a demonstration lecture course on the mining, manufacture and testing of all kinds of bituminous materials; the next two weeks will be devoted to a course on bituminous surfaces and bituminous pavements; while during the final period of two weeks will be given a laboratory course in which those enrolled will test various types of bituminous materials, make analyses of unknown materials, and write specifications covering the use of bituminous materials under varying conditions. Each course will comprise forty lectures or eighty laboratory hours depending upon the character of the course.

During the coming year at Columbia it is expected that another innovation will be introduced inasmuch as, in connection with the graduate work in highway engineering, there will be founded several research fellowships by various manufacturing companies. The research workers holding these fellowships will investigate problems of particular interest

and value to the manufacturing concerns founding the same. It is expected that many problems of wide interest to those engaged in highway work will be thoroughly investigated through this medium. While admirable work has been done along many lines in the research laboratories of our universities, the speaker earnestly hopes that more attention will be given in the next decade than in the past ten years to the multitude of problems in highway engineering which demand the best efforts of investigators for their ultimate solution.

FUNDAMENTALS OF EDUCATION AND THE SPHERICAL-WANT SYSTEM.

BY F. W. SPRINGER,

Professor of Electrical Engineering, University of Minnesota.

Continued from November BULLETIN, p. 154.

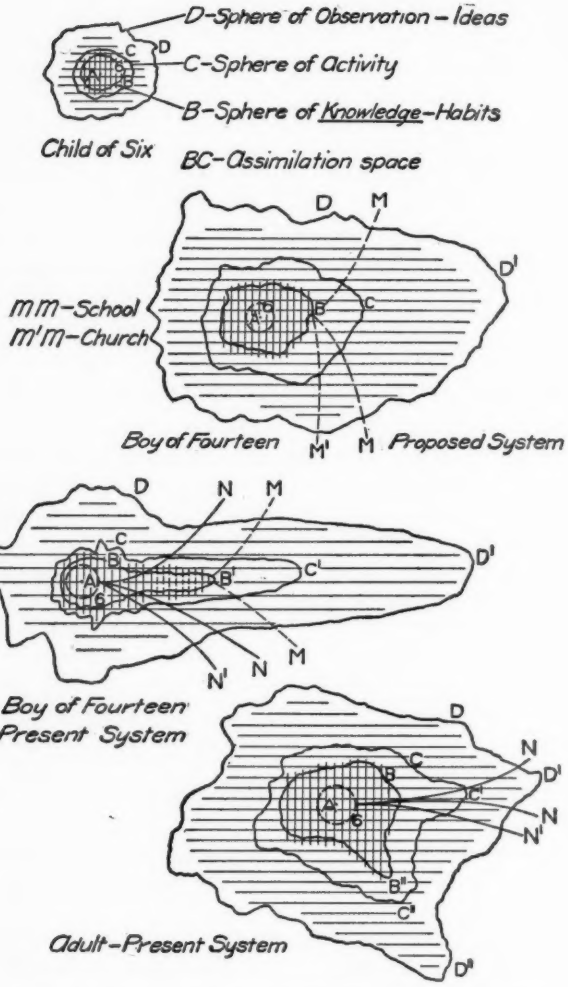
IV.

Diagrammatic Comparison of the Present and the Proposed Systems.

The following diagrams may assist in fixing certain differences between the two systems. Figure 1 illustrates the relation of the various spheres of a child just before the school age. The spheres are shown in section. Beginning at the center, *A* is the individual, *B* is the sphere of real knowledge or habits which have become an integral part of and characteristic of the individual. *C* is the sphere of mental and physical action; the space *BC* includes those actions which have not yet been repeated a sufficient number of times to become "learned," or knowledge. *D* is the limit of the sphere of observation, within which the individual obtains ideas from observations made by means of his senses. Naturally, we should think of the ideas near *D* as being more hazy than those near *C*.

The process of acquiring real knowledge, as shown diagrammatically, is from without inward, the real learning process going on inside of *C*.

The distance outward from *A* may be conceived as "distance," in the sense that an idea not clearly understood is "far" from the mind, or that the real objects connected with the idea are at a relatively great "distance" or "beyond" the individual, and hence not understood. All ideas must, of course, be observed and studied and understood in terms of



Sections of Spheres of Observation, Activity & Knowledge

Sections of Spheres of Observation, Activity, and Knowledge.

FIGURES 1–4.

the real knowledge and experience in the sphere *B*. Mental food or ideas are digested and assimilated by mental and physical action in the space *BC* and *AB*.

It should be suggested that the sphere sections of two persons would be of different shapes, according to hereditary tendencies and environmental opportunities and training. Similarly, the spheres of a person expand with age, opportunity, environment, knowledge, and according to hereditary tendencies, and for the same reason may change in shape as well as size, with time.

Fig. 2 shows sections of the spheres of a boy of, for example, fourteen years, trained by the proposed system. Figure 2, of course, should be relatively much larger than Figure 1, if drawn to scale. The elongation of the sphere at *D'* indicates the main source of ideas, suggestions or stimuli. This should be the school (*MBM*) for a boy of fourteen. The sphere of activity also tends to be closely connected with the school-directed life of the boy, yet since the boy applies school ideas to satisfy his wants, and especially, since the school life is not essentially segregated or different from the outside life, the sphere of knowledge, *B*, may show no one-sidedness.

We may consider a boy's sphere of knowledge well rounded if he has developed the habit of thinking for himself. This implies self-control and deliberate self-direction in his activities and observations. The size of his sphere of knowledge, of course, depends upon the number of **personal experiences** he has built into it, together with a suitable number of **imagined experiences** which he has obtained by reading about and observing others. The larger the ratio of the number of personal experiences to the number of imagined experiences, the more **solid** will be the sphere of knowledge. The quality will depend largely on the character of the experiences.

The means which science affords for observing things otherwise quite "beyond" us have greatly enlarged our spheres of observation and activity. Scientific inventors have for this reason, and others, also, greatly enlarged the common sphere of knowledge. We should expect, then, that these spheres will

increase in size, for the same age, as progress is made in science and methods of teaching. We can even suggest that it may become necessary to limit the spheres of observation of children in order to maintain the quality of their spheres of knowledge. In fact, it may prove that this is exactly what should be done now, especially in the case of city children.

As a contrast to Figures 1 and 2, Figure 3 illustrates diagrammatically the difference in results which might be seen in comparing two boys of fourteen; one being educated by the Spherical-Want System and the other (Fig. 3) being a product of the present school system ($N'GN$). The small dotted circle marked 6, is the original six-year-old sphere of knowledge of Figure 1, and is introduced to accentuate the fact that the present schools produce an "**eccentric**" sphere of knowledge. B and B' are respectively **segregated** parts of the sphere of knowledge of common life and the school. The demarkation shown by the solid line NGN (*cf.* MBM of Fig. 2) indicates the segregating effect of the school, church and Sunday-school. The difference between the very random activities of the boy in outside life and his intensified and "regular" school life is shown by the sphere of activity CC'. Similarly, the school part of the sphere of observation is strikingly regular, being the same for all pupils and lying quite away from the natural life. One might almost conclude that pupils learn more things they ought not to know outside of such a school than things they ought to learn in school.

The one-sidedness of this system and the acquisition of non-used or non-usable knowledge is readily seen by comparing Figures 2 and 3 and noting particularly that the activities of the pupil are directed away from his normal or natural life. The sphere of knowledge, B, shown in Figure 3, is not homogeneous. As shown in Figure 2, ideas are applied and learned immediately, in the proposed system, as distinguished from the idea-stuffing, phonographic system of Figure 3.

Figure 4 shows the sections of the spheres of such a boy as of Figure 3 after having been out of school for a sufficiently long time to have **oriented.** This figure indicates that most of

the school knowledge or habits has been forgotten, because not used. The figure also indicates that the particular individual is finding for himself his natural bent at some trade ($B''C''D''$).

The above diagrams, or attempts to visualize the spheres of knowledge, etc., may appeal to the reader as being like the biological drawings showing the things that come to pass in an egg. But after all, the physical, chemical and physiological changes that go on in the brain and body during the assimilation of knowledge may not differ so very widely if we go back, in both cases, to the fundamental laws of nature.

Our present school system has admittedly many faults. We may group many of them by saying that a large part of the time and effort of our schools and students is spent in building **spheres of ideas,** instead of knowledge, and thus in forming bad habits instead of good ones. (See Fig. 3.) Further, these spheres of school ideas (D', Fig. 3) are quite generally extended far beyond the normal or natural spheres of observation, and especially far beyond the spheres of activity or application of the young. **The present school system bases much on the future application of ideas without clinching the ideas as good habits in the present.** It would seem that our present school system, if named in the terms of the proposed system, should be called, in some respects, the **Non-spherical-Don't-want System,** because the system goes to the extreme in the direction of non-usable knowledge, and too much against the natural wants of children.

All work and no play makes Jack a dull boy, but all play and no work makes Jack a regular rascal. Boys are bound to do something. It is largely a question of what, and not of how much activity. The problem is, then, not so much to keep them busy, but busy at the right thing. There is nothing like inducing a boy to build something he wants, to keep him **busy** and make him useful. A boy of twelve who cannot design and make a really good kite, dog-house, sled, dog harness, and the hundred and one things a boy wants, is simply missing the joys of real living. Wants would grow with his ability to supply them, and a boy would soon learn that mathematics

and drawing are useful in his work. The best time to use books comes when children want the information contained therein. Boys should work harder than now, and do it joyously. It should be the privilege of every boy to go to bed every night tired and sleepy. The discipline should be more severe, and they should discipline themselves, in addition, by electing and obeying their own officers.

The spherical-want system proposes that a boy, or girl, shall actually **learn** things with which he has to do in the increasing sphere of his experiences, and not merely get ideas about his own sphere and about larger spheres of activity of which he knows nothing and for which he has no natural interest. It is such a pity when one thinks about the physics, chemistry, biology, etc., the boys don't learn while swimming, ball-playing, boating, shooting, hunting, and playing.

The vocational courses of the present and future offer a splendid opportunity to make use of the wants of pupils in inducing them to **seek** knowledge for immediate as well as for future use, and to learn first all about things themselves, rather than their names and classification. Vocational training of such a character would undoubtedly develop wants for the purely cultural.

German fortbildung schools, while belonging to the disciplinary type or outside-pressure class (as distinguished from the inside-pressure of individual will) supply approximately the proper sphere of action. They lack, however, the attitude of mind of both teacher and pupil towards each other and towards the work, so necessary to make effective use of the **wants** of the pupils.

The great difficulty with the application of the new system in college and high school vocational courses is that the work is hampered by the habits which the students have formed during their preliminary training, to say nothing of the difficulty of reversing the attitude and methods of the teachers. Since what can be done after fourteen years of age depends so much upon that which has gone before, reformation should be begun at the earliest age possible.

V.

Selection of the Name and Rules of Application.

It is evident from the foregoing that the Spherical-Want System might just as well, in some respects, be called the "Environmental-Want System," "The Natural System," or, perhaps, "The Rational System." The last two would not be distinctive, and hence are not available. As to the name "Environmental-Want System," this name is cumbersome and, further, the term environmental is in common use in a sense somewhat different from that expressed by the terms expanding spheres, spheres of knowledge, activity, observation, etc. An illustration will bring out this point:

An English mother with her little boy of six years stopped in a French pension in Boulogne-sur-Mer for the summer. Among others there was a French family with five children, ranging from three to eleven years. During the first afternoon all the children gathered in the court to play. It was interesting to watch the little English boy get acquainted with the French children, since neither spoke a word of the other's language. In two hours, the French children had picked up enough English words so that with signs they were all playing together like old friends. The English boy was a curiosity to the French children and they wanted to play with him. Johnny Bull, on being asked why he made the five others learn English words instead of his learning French, answered, —"I don't want to." All this happened in a French language environment, yet six-year old Johnny Bull created an English language sphere for the others,—spheres of observation and activity. He was able to do this, though one against five, because they **wanted** to learn English in order to play with him. Disciplinary forces were active also in several forms. Johnny was the teacher and he employed the Spherical-Want System.

This system, as applied at home and in the schools for teaching a foreign language, is thus perfectly clear to any one. In regard to arithmetic, spelling, composition, geography (local),

physics, drawing, isometric drawing, chemistry, etc., etc., **it is the problem of teachers and parents to create spheres with arithmetic, etc., in them.** The rules they need to remember are:

1. "**Teach**" the children those things they **want to use now,** even if you have to teach them a few of the things you learned in college, and treat them as individuals.

2. Keep them, as far as possible, in such a sphere of observation, or in such an environment, as will stimulate the desire to learn the things they should and can learn **now.**

3. Equip their spheres of activity with the necessary apparatus needed **now.**

4. Keep close to the things of nature; avoid the artificial things as much as possible while the children are young. They should be, first of all, perfect specimens of animal life.

5. Apply the disciplinary, prohibitive, regulative and corrective factors of **love,** of **fear,** and of **force.** Punishment should operate as nearly as possible like the pangs which follow a misuse of gravitation or green apples. Punishment should just be, with no feeling about it,—so far as the teacher is concerned. The limits of action or of non-action, as set by nature and society, must be observed.

6. Don't worry about ideas. Children are imaginative enough without many book ideas, and if in the proper sphere, they will have plenty of ideas to work into their own personal experience. The latter they must have, because everything they do or say or want to do or think is in terms of past experience and very, very little in terms of other people's ideas, and even then, only after the ideas of others have been understood in terms of their own.

7. Home, community school and church should be non-segregated parts of the boy's life. Everything he learns about ideas in any of the above should be of such a nature that he can **work** it into a homogeneous sphere of knowledge. Forget about giving him all the other things—until later.

8. Lastly, and most important, the minute a child begins thinking in terms of his own correct experiences, just then,

and no sooner, does he begin to stand on his own mental feet. The teacher or the parent will then be free. The child or pupil will nearly always ask for information when he wants it. He will become a seeker after knowledge. Let the children do the work and the teacher only guide.

Start the system at birth and keep it up. The present system of teaching in the schools forces the teacher to do all the mental work (or nearly all) for the pupils, and leaves the pupils merely the **form** of mental work in classifying ideas already classified—a sort of mental manual labor.

The proposed system would free the teacher of an abominable drudgery and leave him free to really teach.

It now remains to still further bring out the **feasibility** and **desirability** of this proposed system of teaching. This is attempted under the following captions:

Miscellaneous Conditions and Faults.

Efficiency of the Educational Machine and Educational Elements.

Religion of Science.

Money-Life Curves, Wages and Education.

American, French and German Schools and Students.

Modern Trend in Science and Education.

VI.

Miscellaneous Conditions and Faults.

A nation gets out of its schools about what it puts into them. Children, working under an indifferently good system which is influenced by selfish individualism, and who are taught by poorly-trained mediocre teachers, will bring to the expectant nation only national disintegration. A school system which develops the theoretical, cultural, artistic, and other artificial wants and appetites, and does not train the young to apply information in order to satisfy these desires without becoming parasites, can bring only disappointment. **A vocation is a necessity; "culture" only desirable.** This is not an attempt to set vocation against culture, but only to bring out the point

that since people must earn a living the great majority should reach culture largely through their vocations by learning the relations of the great laws of life in their respective spheres of activity. Any school, to be successful, must train students how to think. Education, knowledge, intelligence, or brain power, is the ability to make new combinations of the comparatively few simple elements in life. The problems of even everyday life cannot be solved in advance in school—only the ability to reason through a difficulty can be developed. It is not necessary for each student to study all subjects to acquire this ability.

Human nature is much the same the world over, and at all times; but racial efficiencies or civilizations, and natural opportunities differ widely. If we take account of stock of ourselves as a race and a nation on the above basis, we shall discover that after all, things may not be so very bad—at present. Starvation is rare. Perhaps a large part of our "good fortune" is, however, due to the consumption of our great natural resources, and not so much to efficient training either as regards production or consumption. Our greatest concern, then, is the responsibility for the second or third generation to come. History points to the conclusion that certain tendencies, now very well marked, will lead to trouble in the future unless diverted.

The success of any one generation depends very much upon the education as a whole given it by the preceding generation, so that it is our duty continually to look for faults in our schools and to correct them, as well as to continually make those changes necessitated by modern progress. Just as supply usually follows demand, so also do improvements in our school system naturally lag behind the modern requirements. The increasing severity of the complaints of the public seems to show, however, that our school system is much too far behind. The criticisms are directed not only against engineering courses and other professional lines, but are directed at the whole system of schools. The chief notes in this public complaint seem to be:

1. Lack of **individual efficiency,** in that students are not really prepared for their life work.

2. Lack of **national efficiency,** resulting from poor citizenship training, with too selfish interests and too little interest in the common welfare.

The critics are asking for vocational courses in academic lines, and for similar courses in the high schools. There is also pressure which, sooner or later, will result in some changes throughout the whole school system.

The school problem has been attacked already by many faddists who, after shoving a pet line of work into the curriculum and thus adding to the confusion, have contentedly let the poor teachers struggle as best they may with the additional problem till another faddist comes along and adds another complication, continually adding something but taking nothing out. We have now a complicated school curriculum which as an instrument for mind-stuffing is a great success. In other words, the present educational machine is designed and operated in such a way as to fill the pupils' minds with ideas of various kinds.

The teachers have orders to stuff just as much "education" into the minds of the pupils each day as the schedule indicates. The pupils are all supposed to be prepared to assimilate the mental food tablets which are automatically fed into their individual lives, whether or not their minds are already filled with information which experience alone can dissolve for assimilation. This is much like insisting that a pupil shall eat a definite amount according to a schedule, whether hungry or not, and without considering personal digestive power or taste, *i. e.*, wants.

Everything is so crowded and rushed in the modern school that students do not have time to digest or even chew. They simply bolt a comprehensive menu of prepared facts or ideas, as the only condition under which they may remain with their class. **Forcing ideas under high pressure administration is confused with real education.** The pupils' wants, so far as knowledge obtained in school is concerned, are, on the average,

limited to "pass" in order that they may remain with their class as social units. They do not, in general, expect to obtain information in school that they want to use **now**. Generally, what the pupil or student desires, or what he should desire as a growing animal and human being, is forgotten. Yet the pupil's **wants** are almost his sole incentive to form the habits constituting knowledge. He may have the choice, for example, between writing a composition on spring or taking punishment, but this is a choice between "don't-wants."

Of the two educational extremes, it would seem that our present school system approaches the **cramming type** in which students are treated like cans in a canning factory or like the stall-fed goose system leading to a "pâté de foie gras" degree. This system produces fat heads or, at the best, human phonographs filled with ideas which might be valuable to some one, sometime, if he knew how to use them. The second system, the great **school of experience**, has produced some of the greatest men in history. Lincoln is an example. But this system, unmodified, is altogether too expensive for general application, because there is such a small percentage of a population that could succeed if thrown absolutely upon its own initiative when young. The successful few would be crushed by the burden of the unsuccessful.

It sometimes seems that we think more about the **curriculum** than we do of the students. A subject or course once introduced into a school system becomes holy and is not to be removed, because of the inertia of habit. The result is that in many school years boys are carrying six to ten subjects, each one encircled by its own Chinese wall. This is very confusing and tends to develop a lot of skimmers instead of real students. Three **non-related** subjects, counting class and laboratory as one, should be enough at one time. **If** it were necessary to carry a lot of totally separate subjects, *i. e.*, subjects not readily and simultaneously converged in the mind of the individual **through personal experience**, they should be taught in series and not in parallel.

Certain subjects are listed as prerequisites for other subjects

and pupils are held back a grade on this account for failure in one or more, but, in general, investigation would show that a fairly small part of many subjects is really necessary to the study of some other in the following year. In addition, unnatural divisions are made, many subjects being taught as though they had no connection with anything else in life, when, as a matter of fact, all subjects taught at the same time should be so related and taught that the student would have little difficulty in combining them by his experiences. This, of course, would require active personal coöperation on the part of teachers in departmentalized systems, and considerable freedom as well as breadth of view on the part of those teachers teaching a whole series of subjects. Whether or not the grade teacher connects the various simultaneous subjects into a whole, or whether or not the college teacher coöperates to obtain the same result, the pupil and student must combine the information from the various sources into an individual, homogeneous sphere of knowledge.

A certain college teacher of mathematics said that he wasn't interested in the **application** of mathematics because it was a subject by itself. It is generally supposed that mathematics, mechanics, and the like, are stenographic descriptions of physical relations, the mathematical symbols being used for convenience in manipulation; and that the object of mathematical juggling is to make mathematics simpler and more readily applied. In the case of grade pupils "applied" means real application.

At a certain school in Minneapolis a class was given twelve problems in algebra—a subject, as now taught, having no connection whatever with the average pupil's wants. Each of the members took one problem home, by agreement, and asked a parent to help him work it. The class came together a few minutes before the recitation and exchanged the fruits of their labors on the basis that a fair exchange is no robbery. All of the members of the class had all the problems worked out correctly, and all received full credit, and not one had really earned the credit for a single problem. The trouble with this

is that it is altogether too much like some of our American business methods. If each pupil had been required to work out one problem and clinch the idea by applying it in his own sphere of activity, he might not have learned as much about coöperation, but he would have learned vastly more about algebra and its uses. The difference is exactly that which exists between good habits and bad habits.

Subjects now taught which are elaborations of certain non-fundamental phases of life, a knowledge of which is not likely to be needed immediately, even by a few students, should be reserved for the last layer of the enlarging educational sphere. In the same way, purely theoretical subjects, or subjects quite removed from the sphere of activity or application of the individual, such as certain phases of mathematics, should be left for the last years in college. Investigation would show, no doubt, that a part of some subjects, such as mathematics, mechanics, etc., could, perhaps, be dropped out to advantage and a smaller part studied more thoroughly by **applying each theory within the sphere of activity of the student immediately after studying it in class,** resulting in **creating a want for the information.** This would be almost the first result if teachers in departmentalized systems would confer with the idea of simultaneously approaching the same field of knowledge from different points. The problem is more difficult in the case of the present grade schools, in spite of the fact that a teacher may have all the simultaneous subjects, because the "system" suppresses individual initiative and incentive to understand and apply the fundamentals of education. The voter, politician, and even the members of the school board, who now control the educational policy, too often think of education, or the "public schools," in terms of taxes, buildings, heat, ventilation, medical inspection, number of pupils per teacher, and salaries, when as a matter of fact these are at the most important details. **The teachers, the pupils,** and **the spirit of both, constitute the trinity of education.** We might well approach the subject of education with only these three fundamentals in mind, if it were not that these factors

are controlled by an administrative machine which varies all the way from the will of a private tutor to the complete set of infallibly operating rules of a public school system.

A machine makes no mechanical mistakes. It repeats the idea upon which it is built with exactness, and when supplied with administrative driving power never fails to "bust out" a student who may not happen to fit one or more of the educational courses through which he is being shoved, nor does a machine fail to produce uniform results—uniformly bad or good. Students being human and varied cannot always fit all the grooves, so the machine makes many human mistakes. Many college departments have attempted to avoid machine errors by giving the executive head large discretionary power or by turning over the exceptional student to a committee of active and young teachers, some of whom know the individual student. Such committees make mistakes, but they do not make as many human mistakes as the machine.

The extreme in non-machine rule is that in which students are allowed full freedom till they appear before an examining board for a degree. Such a system could not succeed at the present time, even in college work, in the United States.

The indirect effects of machine control are greater than the direct, since anything that affects the spirit, incentive, and selection of teachers affects the pupils. In most cases the executive may determine the form of control, selection of teachers, coöperation, method of teaching and spirit, although the kind of teachers available for choice depends upon salary and upon the schools for preparing teachers.

In order to bring out certain school limits as well as school faults the following brief outlines of the **spirit** and **control** factors in the university, high school and grade schools are given:

Colleges and Universities.

1. **Educational methods** and policies practically controlled by the teachers and executive.

2. **Departmentalization,** with teaching done by specialists,

a maximum. A tendency toward greater and greater specialization and less coöperation among the teachers in respect to time and subjects taught. Each teacher tends to go higher and narrower in his activities, constructing a cone-like projection on his sphere of knowledge.

3. **Freedom of action** on the part of individual teachers very great and the spirit of teaching highly developed.

4. **Responsibility** of the teachers placed by the executive, by the alumni and students, and in some cases by examining boards, as in the case of lawyers and doctors.

5. **Incentive** to apply the best methods of teaching rather great but depending largely upon the spirit and methods of the executive rather than upon the responsibility placed upon the teacher.

6. Great danger of **failure to coöperate** due to highly developed spirit of teaching, specialization and individual freedom.

High Schools.

These schools with their " junior " academic and engineering courses are quite comparable to the universities, in the social life, sports, kinds of subjects taught and general educational control. Each high school tends to become a junior college in form. There is, however, less freedom of action on the part of the executive, greater mechanical control of teachers and pupils, less initiative and less spirit of teaching than in the universities. This difference is due to three factors among others, politics, lack of masculinization and to the immaturity of the pupils, which prevents the pupils' entering as a factor as in the colleges. Responsibility is determined by the executive, by a non-trained public's opinion, by entrance requirements of colleges, and by high school board examinations.

Grade Schools.

The grade schools, especially the upper grades, similarly tend to take the form of high schools. Owing to the imma-

turity and dependence of the pupils, lack of masculinization, the size of the system, politics, training of teachers, and character of executive, these schools differ greatly from both the high schools and universities, as follows:

1. Educational methods **not** controlled by the teachers. Many of the essentials of teaching are conducted by a man miles away from the pupil through the teacher as an instrument.

2. Only a tendency toward departmentalization.

3. Practically **no freedom** on the part of the individual teacher as to methods, subjects or books.

4. Responsibility placed upon the teacher very great and of a machine character.

5. Very little incentive to study the fundamentals of education or to apply them.

6. Spirit of real teaching lacking, with danger of completely missing one of the three great elements in education, the teachers becoming merely educational force-pumps.

In general, there is a lack of " spirit " in the grades, with the resulting lack of correct methods, and a lack of subject coöperation in the case of universities.

The solution of the difficulty in the case of the higher schools is for each instructor to learn **how, when** and **where** the information he imparts is to be used in other courses, and teach accordingly. This applies particularly to specialized courses extending perpendicularly through the whole college career, as in engineering. Such coöperation would result in several teachers acting as one instructor in so far as the effect upon the pupil is concerned. As an illustration, we might take shop work (materials and methods), inspection trips and reports of the same, construction studies as of dynamos together with suitable courses in mathematics and physics and chemistry. Another group might be running tests and theory (as of dynamos or engines) and plant operation together with suitable mathematics, etc. It is a waste of time to study the theory of operation or design of a dynamo, boiler or engine by a student who does not thoroughly understand the con-

struction details and who has not yet operated the machine. It is a waste of a large part of the time to study mathematics with no conception of its use.

In the case of the grade schools it would seem to be a problem of how to give the teacher a "**faculty vote**" as to educational policies and methods and at the same time hold the teachers responsible for results. This will require much education of both teachers and the public. Without such a solution there will never be the proper "spirit" in the grade schools. With the right spirit and incentives it would not be long before the best methods of teaching would be adopted. Such an improvement in the lower schools would greatly affect the higher schools.

National Faults.

Many of our national faults find their counterpart in school life. Perhaps the railroad disasters, bursting dams, steamboat disasters, loss of life in fires, are reflected in school life by the guesswork system of skimming a subject with the sole object of obtaining enough ideas to pass it, without a sure and convincing application and with no desire or need to make an application. The willingness to trust to luck in preparing for recitations for which there is little personal incentive or desire for the knowledge, the large amount of matter to be "learned," all develop a tendency to slide over or evade the exacting details required by application. Students are promised personal success if they are good students and "learn" the things forced upon them and which they are expected to accept on the judgment of their instructors as being very useful in the future. Students are occasionally exhorted to be good citizens, but they are not generally shown how to be, by organizing them into active citizenship communities, in which each pupil is an active unit. It was reported that in a city not a thousand miles from Philadelphia there are over 100,000 legal voters who regularly shirk the duty of voting in elections. They are the educated and "best citizens." In general, business men, for example, will look up every reference in hiring

a janitor or clerk or stenographer, let alone a manager, yet they may give only a few minutes a year, unless specially interested, in looking up a candidate for alderman or governor. This is because they, as boys and men, were not trained to select leaders. It is simply a matter of habits, which they have never formed, of selecting leaders.

There are some characteristics noticeable in America which we may combine and say are due to a lack of home and school discipline. Perhaps these faults are due to the tendency of parents to leave discipline to the schools, while in the schools there is nothing that approaches real military discipline. The qualities referred to are individualism and lack of respect, combined with selfishness which results in indifference towards community interests and a lack of sense of state. We might call all of this general thoughtlessness of others. There are some things in the account of the death of Mr. Ely, the aviator, that seem to be connected with the above faults.

"A gruesome feature of the death of aviator Ely here this afternoon was the fight of the spectators to procure souvenirs of the tragedy. . . . In a few minutes the littered field was cleared of every bit of wreckage. Ely's collar, tie, gloves and cap similarly disappeared, the collar being taken from the body."

Selfishness, up to the point of obtaining the necessities of life, is a very commendable quality and a necessary element in the survival of the race. But when certain rich men, magnates and soulless corporations have demonstrated that in order to multiply millions for the purpose of increasing their power, they are willing to avoid and break the laws of the state and to bribe legislators, with indifference to the needs or rights of the many and the common welfare, we must see to it that the young learn to coöperate, by coöperating while children in the interests of the many and against the few. It is difficult to teach an old dog new tricks. Our hope lies in instilling a sense of state in the young while yet in school, that they may later coöperate to provide the social, political and commercial corrections needed at present. If reform is not

made by this method, it will, of course, be made as a result of the popular education following some sort of a revolution. When the people begin to separate into class camps, one enjoying special privileges by virtue of influence upon lawmakers, and the other resorting to dynamite to enforce its claims, the time has arrived, not only to think, but to act. Dynamite and bribery are more closely related than many people suppose.

Doctor Kerschensteiner, in his book entitled, "Der Begriff der Staatsbürgerlichen Erziehung," quotes from the report of the "National Educational Association of the United States":

"The common schools of our country (United States) must recognize more fully than ever the necessity of training our youth for citizenship."

Doctor Kerschensteiner then expressed the following opinion:

"Je eingehender ich die amerikanischen Schulverhältnisse studiere, desto mehr schwindet meine Furcht vor ihnen, so lange ich die Hoffnung haben kann, dasz wir diese Frage besser und eher lösen als andere Staaten."

If we do not want the definition, which seems to apply to many American politicians, to hold true—that "A politician is a conceited ass ridden by those who know exactly where they want to go"—we must see to it that pupils and students practice electing and selecting their leaders, while in school, on a basis of **honesty, ability,** and **special fitness.** The young must form the habits, and form them early.

In the case of a republic it is a difficult thing to start improvements, because the opinions of large masses of people must be brought to agreement before action can be taken. Without public spirit, reforms in a republic, even in the school system, are very difficult. Our people seem to need a great adversity or disaster to make them all think about the same thing at the same time, to induce them to take a common line of action. The Chicago theater fire, in which six hundred women and children were burned, almost made the voters of Chicago realize their responsibility. The Slocum disaster aroused some expression of opinion, but it did not result in much steady, forceful action on the part of voters. The

account of the buying of a senator's seat is merely interesting reading to a great many voters. As long as living comes easy and it is a question of getting rich, and not one of starvation, people will not trouble about general questions. It requires much education of the public to cause great reforms to be made in the interest of the second generation.

When one thinks of the mass of people which must be moved to start a reformation, and when one considers the number of children as pupils and students in schools of America and bears in mind the relation of education to life as a whole, the problem of education becomes of staggering importance. About one fifth of our population is in the school system.

Many of the faults in our educational system seem to be due to inability to keep up with those advances made in science, partly, in turn, due to the educational system. Other faults are due, possibly, more to the fact that our educational system reflects our national life with its faults of exaggerated individualism, a form of selfishness, lack of sense of state, carelessness, lack of discipline, and a restless, reckless determination to become rich and happy somehow. Education may correct these national faults, but it is not the whole cause of them because **national ideals and education are each dependent upon the other.**

While the faults of American life and schools noted above, and others, are of great importance and should be remedied, no correction should be made in the school system which does not take into account the probable future development of science and the trend of civilization.

(*To be continued.*)

JAMES DYNAN NEWTON,
1871–1912.

James Dynan Newton, dean of the engineering school, Loyola University, Chicago, Illinois, died at the U. S. Marine Hospital, Chicago, on August 8, 1912. Death came very suddenly after an illness of only one week, following an operation for stomach trouble. Born in Oswego, N. Y., in 1871, Mr. Newton was graduated from Holy Cross in 1891 with the degree of A.B., and from Cornell University four years later with the degree of M.E. (in E.E.).

Soon after graduating from Cornell, Mr. Newton was appointed cadet engineer in the U. S. Revenue Cutter Service. In 1896 he was commissioned third lieutenant of engineers and in this capacity saw service in the Spanish-American War. He served five years as assistant professor of civil engineering at the University of Kansas and in 1911 was elected dean of the engineering school, Loyola University.

Elected a member of the Society for the Promotion of Engineering Education in 1908, Professor Newton took an active interest in the work of the Society. An article from his pen on the teaching of English in engineering schools appeared in Volume XIX of the *Proceedings*.

FRANCIS H. STILLMAN,
1850–1912.

Mr. Francis H. Stillman, president of the Watson-Stillman Co., and a prominent figure in machine tool and engineering industries, died suddenly at his home in Brooklyn, February 18, 1912. Born in New York February 20, 1850, Mr. Stillman

was graduated from Yale University in 1874 with the degree of B.S. He was a member of various social and industrial societies, among them the Hanover Club of Brooklyn, the Engineers Club, the American Institute of Electrical Engineers, and a director of the National Association of Manufacturers. He organized the Machinery Club of New York, and was first president of this and of the National Metal Trades Association. In addition to being president of the Watson-Stillman Co., at the time of his death he was president of the Bridgeport Motor Co. and of the Pequanock Commercial Co. and a director in other manufacturing firms. Mr. Stillman was generally recognized as one of the most prominent American engineers on hydraulic machine and tool construction, and his firm has built upwards of 4,000 different types of hydraulic machines. His loss is keenly felt in a wide circle of friends in the industrial and social world.

COLLEGE NEWS.

University of Maine.—A committee of the Boston Alumni Association has been appointed to discuss with Dean Boardman plans for the formation of a branch of the University of Maine employment bureau, which is organized for the purpose of obtaining positions for Maine men. It is planned to have branches in several of the larger cities, under the direction of the alumni, who will work in conjunction with the dean of the College of Technology. One branch is already in operation in New York City and others are in process of formation. Much interest is being shown by the different alumni associations and it is expected that the movement will bring the institution in closer touch with them. The members of the committee are: S. P. Graves, '03, representative at large; H. S. French, '86, civil engineering; E. E. Palmer, '99, electrical engineering; E. O. Goodridge, '85, mechanical engineering; E. R. Berry, '04, chemistry.

University of Manitoba.—The following appointments have been made in the Department of Civil Enginering. Mr. Ellis E. Bankson, of the University of Pittsburgh, has been appointed lecturer in materials and hydraulics. Mr. Robert W. Moffatt, of the University of Toronto, has been appointed lecturer in descriptive geometry and drawing. The University has been given a site of 160 acres at Tuxedo Park which it is now improving, and arrangements are being made to start building within a year. The total attendance at the University this year is about 350 students, divided between arts, science and engineering.

Columbia University.—The following non-resident lecturers in highway engineering at Columbia University have been appointed for the 1912–1913 session: John A. Bensel, New York State engineer; William H. Connell, chief, Bureau of Highways and Street Cleaning, Philadelphia; Morris L.

Cooke, director, Department of Public Works, Philadelphia; C. A. Crane, secretary, The General Contractors Association; Walter W. Crosby, consulting engineer and chief engineer to the Maryland Geological Survey; Charles Henry Davis, president, National Highways Association; A. W. Dow, chemical and consulting paving engineer; Walter H. Fulweiler, engineer, research department, United Gas Improvement Company; John M. Goodell, editor-in-chief, Engineering Record; D. L. Hough, president, The United Engineering and Contracting Company; Arthur N. Johnson, state highway engineer of Illinois; Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment, New York City; J. C. Nagle, professor of civil engineering and dean of the school of engineering, Agricultural and Mechanical College of Texas; Harold Parker, first vice president, Hassam Paving Company; H. B. Pullar, assistant manager and chief chemist, American Asphaltum and Rubber Company; J. M. F. de Pulligny, ingenieur en chef des Ponts et Chaussees, et directeur, Mission Francaise d'Ingenieurs aux Etats-Unis; John R. Rablin, chief engineer, Massachusetts Metropolitan Park Commission; Clifford Richardson, consulting engineer; Philip P. Sharples, chief chemist, Barrett Manufacturing Co.; Francis P. Smith, chemical and consulting paving engineer; Albert Sommer, consulting chemist; George W. Tillson, consulting engineer, Borough of Brooklyn.

University of Illinois.—Professor Edward C. Schmidt, of the University of Illinois, announces a gift from The Midvale Steel Company of Philadelphia, of four axles and four pairs of supporting wheels for the new locomotive laboratory which is now under construction. These wheels and axles constitute one of the most important and costly elements in the locomotive laboratory equipment, and the gift is a very generous and unusual expression of interest in the work of the railway engineering department. The axles and wheels are the finest product of this sort obtainable.

Rensselaer Polytechnic Institute.—Mr. H. J. Klotz and Mr. P. K. Miles, of the University of Illinois, 1912, have been

DEPARTMENTAL ORGANIZATION AND EFFICIENCY.*

BY HUGO DIEMER,
Professor of Industrial Engineering, State College, Pa.

In the preceding outline of the work accomplished at our department meetings and in my discussion on the results of experience in teaching scientific shop management† I have outlined some definite and concrete accomplishments. In view of the above results attained it may not be out of place to add a few thoughts and suggestions to accompany the many others which have been made in the direction of furthering academic efficiency.

I believe there is a splendid opportunity in the colleges and universities for work in providing means for attaining higher efficiency by the individual instructor and for the development of loyalty and enthusiasm among members of the instructing force by systematic investigation and resultant action.

A systematic canvass made of all members of the instructing force in which each member would be asked just what is needed in his work to make him more efficient, and from each department and sub-department head as to what is needed to make him and the respective members of the teaching force under his jurisdiction more efficient, would if carried out in the proper spirit result in the accumulation of many suggestions. Some of these suggestions would be impracticable; some of them would be negative; but it is reasonably certain that there is a sufficient number of members in every teaching force with sane and positive constructive ideas for betterment

* Closure of paper of same title in June BULLETIN, pp. 550–552.
† PROCEEDINGS, Vol. XIX., p. 153.

to guarantee that such a canvass would result in the securing of many ideas possible to carry out.

Talking from the point of view of a man who has spent a goodly number of years in commercial work and has seen capable men develop in the employ of large corporations, it is my opinion that few educational institutions are inefficient because of insufficient working hours or an insufficiently hard day's task demanded of the instructor. In industrial work men of the mental calibre of college instructors are provided far more help in the way of stenographers, clerks and draftsmen than is provided in colleges. In industry a department head is encouraged to avail himself of whatever help is needed in the way of stenographers, clerks and draftsmen to make him a more effective producer. In practically every college in the United States the individual instructor must be his own stenographer, keep his own records, and do his own drafting, thus reducing his productivity and efficiency in his specialty anywhere from twenty to eighty per cent. In practically every college in the United States, department heads are insufficiently provided with stenographic, clerical and drafting help and must make negotiations with administrative officers for the loan of such help from administrative offices which have also usually an insufficient supply of it.

In very few colleges in the United States are individual instructors provided with private study rooms where they can study free from interruptions at certain definite periods. In attempting to introduce commercial efficiency some governing boards and administrative authorities require instructors to be at their desks during college hours. Such a requirement if accompanied by private study-rooms would be no hardship and would be welcomed by most teachers, as it would tend to shorten the necessary night work which must be done by every teacher no matter how competent, in the preparation of his next day's work. This constant night work by all capable teachers, much of which must be done after social functions and night meetings of faculties and committees, is usually not realized by critics outside the educational field.

At the Pennsylvania Railroad Company's School for Apprentices at Altoona there are three teachers. These teachers are provided the entire daily services of a man who acts as clerk and stenographer. As a result the instruction papers, notes, references, records, etc., are in excellent order. If the industries consider it worth while to do away with avoidable fatigue and also with clerical work by teachers not trained in that direction, why not educational institutions?

Are educational institutions systematically providing for the development of the individual instructor so that he may see more efficient methods and become more efficient himself? So far as concerns visits to other institutions they are not. While engaged in industrial work I have frequently had occasion to show methods of the establishments with which I was connected, to engineers, superintendents, foremen, and cost department clerks who were sent out on visiting trips by other establishments for the purpose of acquainting them with the methods of other companies. To some extent such visits are made by members of college teaching staffs. However, they are usually made by deans or heads of departments and generally only on such occasions as the establishment of a new laboratory or the equipping of a new building. Such trips are seldom instituted and authorized for teachers in the ranks to be taken at times when the work is in active progress at the institution visited.

In addition to the systematic inquiry into means for development of individual efficiency, I would recommend a similar systematic canvass as to means for development of loyalty. Systematic and continuous efforts must be made to make the individual teacher's work inspiring and to get each man interested in his work. The system of promotion must be such as to afford numerous examples whereby ambition may be preserved. Fair play for all and the avoidance of sharp practices in dealing with employees have been recognized as vital principles in developing loyalty in the industries, and these same principles should prevail in all educational organizations. The individual teacher should be en-

couraged to undertake tasks of public service, to do research work, consistent with his teaching duties, and to write papers over his own signature. The progressive department head will realize that such encouragement of the individual teacher will tend to strengthen his department and add to the prestige of the department head. Social recognition, graciously accorded to the individual teacher by the department head in introducing him and his work to visitors on public and semi-public occasions will do much to develop loyalty.

I believe the foregoing phases of academic efficiency are worthy of more attention than has been accorded them in the past.

In my discussion on the results of experience in teaching scientific management I dwelt particularly on a single phase of our four years' course in industrial engineering, namely, the class in machine shop time study. We have already graduated three classes in our four years' course, and a brief outline of the classes peculiar to this course may be helpful. The course is identical with the other engineering courses in the freshman and first semester of the sophomore year. In the second semester of the sophomore year a lecture and recitation course is introduced on foundry and pattern shop organization and methods. In the junior year classes are introduced in machine shop organization and methods, a course in machine shop time study and English economic history in the first semester. In the second semester manufacturing accounts and factory economics are taken up as well as American economic history and logic. In the first semester of the senior year factory economics is continued with especial attention to scientific management. Principles of economics, labor problems, corporations and finance, and also psychology are also taken up this semester. In the second semester of the senior year a designing room course in factory planning is taken up, also contracts and specifications, a continuation of corporations and finance, also an option between political parties, railroad economics, or money and banking.

The mathematics, science and language work is identical

with that in all our other engineering courses, while the machine design, heat engineering, electrical engineering, and experimental engineering may be said to represent about as much electrical engineering as is given to mechanical engineering students and about as much mechanical engineering as is given to electrical engineering students.

Our four years' course in industrial engineering is a decidedly different training in scientific management from a one or two hours' per week class in which an attempt is made to combine theory of accounts, contracts and specifications, cost accounting and scientific management, using a single text for the entire combination.

I have been asked by several prominent engineering educators "Why do you teach engineering or mathematics in your course at all?"

It is needless to say that this question has never been asked me by industrial managers, who realize that though the industrial engineer must coördinate the commercial and the human with the technical, he must first of all be a thorough engineer, capable of technical counsel and superintendence of the technical elements of industry.

EDUCATION AND MODERN PROGRESS.

BY L. MAGRUDER PASSANO,

Assistant Professor of Mathematics, Massachusetts Institute of Technology.

The writer has been interested and entertained by Mr. Harrington Emerson's article on "Educational Demands of Modern Progress," but feels that exception must be taken to some of its statements and conclusions.

It does not seem true that " past knowledge, past experience, past skill " count for less in these days than ever before in history, nor is the writer willing to admit that " never before . . . have men been so poorly prepared for what is ahead of them."

Our problems are difficult and our burdens are heavy, but no more difficult or weighty for us than were those of the seventeenth century for Newton and Leibnitz, those of the third century B. C. for Archimedes, or those of prehistoric times to the men who were replacing the stone axe by the bow and arrow.

It is true that our way of meeting the difficulties is different. We are more in haste, we have less patience, and it is to be feared that immediate personal aggrandizement is a more powerful motive than mediate benefit to humanity.

Mr. Emerson seems to say that routine, in ages past, was the only law of progress, because " we are now in . . . an age requiring for survival initiative and not routine "; men died where they were born, and women knitted and spun from dawn to dewy eve and from early youth to age. But, surely, in times before our " peculiar epoch " a Roman soldier, born in Britain, might lie down to die on the banks of the Euphrates; a trader, born in Asia Minor, might meet his death on the coasts of Gaul. Not every Northman returned in

safety from the coasts of Africa where he went seeking ivory and gold, nor every crusader from the Holy Land where he sought glory for himself and his religion.

The women who came to Lord Baltimore's colony and those who came to Massachusetts Bay did other things than knit and spin; and the thousands of women and children who helped to break the way into our undeveloped West had the routine of their lives rather roughly broken by Indians and wild beasts. But they, presumably, did not live in "a peculiar epoch . . . requiring for survival initiative and not routine."

The writer cannot, of course, know what Mr. Emerson learned in that "one of the foremost technical schools in the world," but he is absolutely certain that very many things "of engineering importance today" were taught there. The writer is sure that Mr. Emerson was taught the fundamental principles of mechanics, that he was taught the meaning and applications of integration and differentiation, and that the laws of trigonometry were not hidden from his view.

To be sure, this was all knowledge of the past, and Mr. Emerson condemns his teachers for teaching him what they knew, rather than those things of which they knew nothing. He complains that they taught him "not a word of dynamos . . . or telephones . . . or aeroplanes." As well might the men of Greece and Rome complain that the philosophers taught them nothing of gun powder, nor of the printing press, nor of steam railways.

Like every other human being Mr. Emerson was trained for the future by a knowledge of the past; by the general and fundamental knowledge of the past he was trained for the solution of general and fundamental problems of the future. How could he be explicitly trained for a definite and *unknown* future problem?

The writer regrets to hear that "the changes in the last fifty years have . . . scrapped most of [even] the technical experiences of the past," and he refuses to believe that those changes "have profoundly modified moral obligations." He still believes that it is wrong to steal and right to be honest—

even on a large scale; and he still believes that even the great leaders of industry and finance should be kept within the "routine bounds" of moral obligations. And he believes that *all* men should be bound, not by a "twenty-first century conception of the golden rule"—whatever that may mean—but by an all-the-centuries conception of the golden rule; and by ethical ideals worthy of man himself in his best moments, not by those "worthy of the telephone, wireless, gas engine" and other machines which man has made.

"The good things in the universe" may not be "limited," but the writer would like to see the results of a "straw vote" on the question as to whether there is a limit to the good things of this world. And if Mr. Emerson has devised some plan to utilize the heat of those fine suns, "*rescued* . . . from the bottomless void," the writer is convinced that there are thousands of men who would like to hear of the plan before the advent of winter.

The writer rejoices—with all due apologies—that we still teach our children to read fairy tales instead of to watch moving pictures, believing that thus we train their imagination toward the higher things of the spirit. We teach them to write, we teach them to multiply, to add, and to draw, because we know that a child's mind is his most important part, and because we wish him to be a thinking human being, not a machine for counting-house or factory. The educator's work is to produce the thinking, human product.

"What is the fault of the whole educational system?" Educators do not know. Mr. Emerson apparently does. Nor will educators admit that the system is wholly at fault. It is, like every other human institution, neither perfect nor wholly bad.

Assuming with Mr. Emerson that "routine" is the fault of modern education, and that "initiative" is its panacea, let us see where we shall be led.

"Engineering students must be taught to distrust all the traditions of the past." They must distrust the law of gravitation, and be ready to believe that water will run up hill.

They must distrust the law of the lever, and refuse to use a crow-bar. Because "'what is' is probably wrong."

It is a "tradition of the past" that perpetual motion is impossible. Therefore, let the student distrust this tradition, and instead of grinding away at the "routine" of calculus and mechanics let him "guide himself . . . by the eternal stars," let him take the "initiative" and invent a perpetual motion machine. Before now youth has been advised to "hitch his wagon to a star."

"Initiative" cannot be taught. The "initiator," the originator, the genius, like the poet, *nascitur non fit*. All that education can do is to train the genius, as it trains the common man, in the great knowledge of the past, so that in his striving ahead he may not waste his energy in futile efforts to achieve impossibilities.

May the writer be allowed a question in retort? What is the fault of those who criticize the educational system from the point of view of "efficient" progress?

First, the attempt to apply principles derived from a study of factory and shop to the educational system, of which the conditions are fundamentally different.

Second, the tendency to look at education from the narrow viewpoint of their own particular needs instead of from the broad viewpoint of the needs of the human mind.

Third, the indulgence, on the one hand, in generalizations whose bearing upon the subject of education is small and whose meaning is less; and, on the other hand, in the trivial criticism of unimportant details.

Fourth, the assumption of infallibility, often the accompaniment of insufficient knowledge.

The educator wishes help, guidance and advice; he welcomes criticism; he will even try to accomplish the impossible; but he must first be convinced that what he does will help the student to become a broadly and deeply developed, as well as a useful, man.

THE ENGINEERING LABORATORIES OF THE ROYAL TECHNICAL UNIVERSITY AT CHARLOTTENBURG, GERMANY.

BY ROYAL R. HEUTER,

Instructor in Mechanical Engineering, Massachusetts Institute of Technology.

The subject of the following paper is "The Engineering Laboratories of the Technical University at Charlottenburg, Germany." Since the institution may not be familiar to some readers, the writer takes the liberty of introducing the subject-matter which bears on the laboratories by a very brief description of the school, in order that it may be more easily possible to grasp the significance of the laboratories in their relationship to the school as a whole.

The Technical High School of Berlin at Charlottenburg came into existence through the union of two schools, the Academy of Architecture and the Industrial Academy. Originally located in separate buildings and at some considerable distance from each other, the idea was conceived, even previous to their incorporation as a single institution, of housing them under one roof. Owing to the impossibility of finding a suitable location within the limits of Berlin itself, a plot of ground about 18.7 acres in extent and lying in the adjoining city of Charlottenburg, was finally selected.

The site (Fig. 1) with its park-like decorations and with its principal building facing almost northwards, is approached from Berliner Street by a series of broad steps, embellished by a semicircular drive and shrubbery. The principal building, which with the extension accommodates the departments of architecture, civil and mechanical engineering, naval architecture and general sciences (Fig. 2), contains three stories and basement. It has, including all projections, a length of

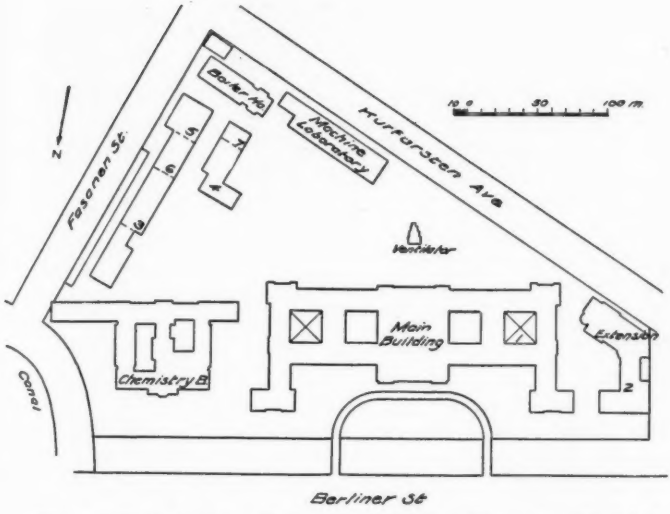


FIG. 1. Charlottenburg Technical University Site. (1) Electrical Laboratory. (2) Laboratory of Mechanical Technology, (basement). (3) Laboratory of Strength of Materials. (4) Electrical Engineering Experiment Station. (5) Laboratory for Combustion Motors. (6) Experiment Station for Elements of Machine Design. (7) Experiment Station for Machine Tools.

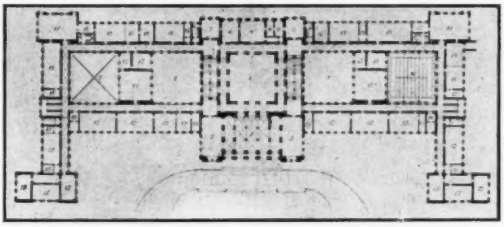


FIG. 2. Principal Building, Plan.

748 feet, a depth of 295 feet and includes five interior courts of about equal size, 75 feet on a side. The upper edge of the

attic surmounting the central portion is 105 feet above the pavement of the street. The great length of the building necessitated a good grouping of the ground plan to avoid the appearance of monotony in the general view in elevation. For this reason the wings at both ends extend forward beyond the front 106.5 feet, and the central portion, too, forms a projection of 42.7 feet (Fig. 3). The vigorous composition of the façade of the latter and the variety in the color of the building-stone used in the various courses assist remarkably in avoiding uniformity and monotony. Rich sculptural ornament on the central portion and the end wings add to the charm of the façade. The rear (Fig. 4) of the building, facing the park, though less ornamental than the façade, is by no means displeasing.

A few steps to the east of the principal building is the Chemistry building (Fig. 1), in which are located the departments of mining and chemistry. The exterior of the building (Fig. 5), is plain and there is a marked absence of ornament. The view is only partially correct, as two wings which have been recently added, extending to the east and west, are not shown.

As originally planned, the two buildings just described provided accommodations for 2,000 students. The excessively high attendance at the school during the years 1900–1904, however, and the consequent lack of accommodations in certain departments, notably mechanical engineering and naval architecture, made necessary the erection of an extension which was completed in 1902 (Fig. 1). The original buildings together with this structure and the extensions to the Chemistry building already referred to provide accommodations normally for about 3,000 students and listeners at the present time. This is of course exclusive of a number of buildings used as laboratories and located on another portion of the grounds.

Let us pass to a brief consideration of these laboratories, their equipment, scope, objects and methods of instruction.

FIG. 5. Chemistry Building, Facade. FIG. 3. Principal Building, Central Portion.
FIG. 4. Principal Building, Rear View. FIG. 6. Electrical Laboratory, Interior.

Up to the time of the World's Fair Exposition in Chicago, 1893, there existed at none of the German engineering schools anything worthy of the name of an engineering laboratory. In a few cases, it is true, a modest equipment had been installed, as, for example, in Münich, Stuttgart and Darmstadt which enabled the professors to carry out before the eyes of the students a limited number of experiments, principally on the then prevalent types of heat engines. The opportunity rendered available for a close inspection and investigation of American industrial and educational conditions in connection with a visit to the exposition above mentioned was taken advantage of by a number of German professional men and educators. What they saw at our technical institutions in the way of engineering laboratories brought home to their keen minds the great practical and scientific value of properly arranged and organized machine laboratories for the instruction of engineering students and for purposes of research and investigation—laboratories where the students should work as independently as possible, and should carry out the experiments themselves in small groups of from 5 to 6 members.

To the energy and determination of these men combined with the remarkable coöperation of the industries and the state is due the inception and completion of a system of laboratory equipment and instruction in the engineering universities of Germany after the American prototypes. Foremost among those who advocated such an installation was Professor Riedler, an engineer of international reputation, and a member of the faculty of the mechanical engineering department of the Charlottenburg school. We shall see below how in addition to exerting his influence he assisted in a very material way in the establishment of the first laboratory at Charlottenburg.

It is not to be understood from what has just been said, however, that laboratory-methods and equipment as such were unknown at Charlottenburg. For a long time the school had possessed an excellent physical laboratory, which, as connected with the department of general science, does not con-

cern us here. Further, there was already in existence at the beginning of the period to which I have referred, the electrotechnical laboratory, for the instruction of engineering students in the theory of electricity and in electromechanics.

As the electrical course is simply one of the options of the mechanical course, this is accordingly one of the laboratories which comes under our consideration. It is located in one of the interior courts of the main building (Fig. 1). and is admirably lighted from above by a glass roof. A view of the interior is shown in Fig. 6. The work done here comprehends experiments on the characteristics of dynamos and motors, hysteresis tests on iron, and practice in electrical measurements. The students work independently or in groups of 2 or 3, as may be necessary, and prepare the apparatus for the tests themselves. Written reports of each test are required and suitable blank forms are supplied for this purpose.

In 1895 it was decided, in view of the fact above referred to, to build and equip a machine laboratory. From the outset its object was twofold: first, to provide instruction in and to give the students in engineering the necessary familiarity with and practice in the operation of such machines as they would be called upon to deal with in practical life; and second, to provide for the carrying out by the laboratory staff, advanced students and others, of investigational work in the solution of problems which arise in practice.

The original plans* called for a machinery hall about 33 feet broad and 184 feet long, and an adjoining two-story structure for the accommodation of the director, the assistants, and for a small lecture hall, and for a work shop and a storage battery compartment. The floor space has been increased subsequently by at least 50 to 75 per cent. The location chosen was at the rear of the grounds (Fig. 1) of the school and adjacent to the boiler house in which were set up the additional boilers made necessary by the demands for larger quantities of steam by the laboratory.

* See also E. Josse, "Mitteilungen aus dem Maschinen-Laboratorium der Kgl. Technischen Hochschule zu Berlin," I. Heft, R. Oldenbourg, Münich & Berlin, from which the views are taken.

Fig. 7 shows a general view of the exterior of the completed structure, and Fig. 8, a section, indicates the general type of construction. A general view of the interior is afforded from the cut (Fig. 9), taken from the easterly end.

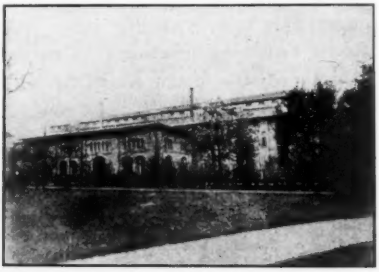


FIG. 7. Machine Laboratory, Exterior.

It was only by the greatest exertions that the grants on the part of the government of the sums necessary for the erection

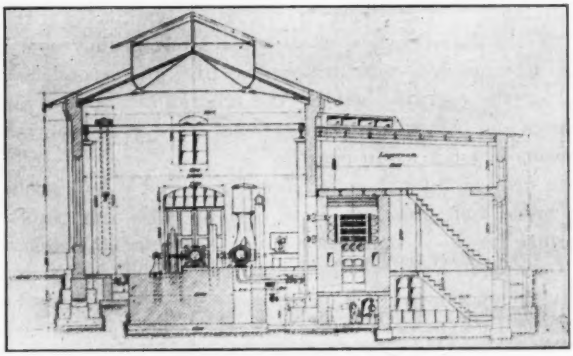


FIG. 8. Machine Laboratory, Section.

of the structure were obtained, and the question of the nature and the extent of the equipment was still unanswered in 1897, a year after the building operations had begun, when Pro-

fessor Riedler came forward and offered to present to the laboratory several large steam engines and a variety of smaller machines to the total value of 120,000 Mk. (equal in value to perhaps 60,000 dollars). A proposal to utilize these machines for the generation of electric power was looked on favorably by the educational authorities and the necessary funds for the additional equipment granted. The entire work was completed in 1899, on the one hundredth anniversary of the founding of the university.

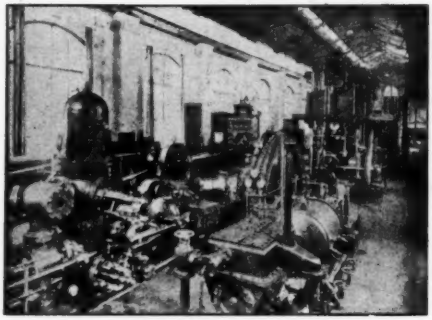


FIG. 9. Machine Laboratory, Interior.

In the foreground of the view (Fig. 9) the first of the machines presented by Professor Riedler may be seen. It consists of a 60 h.p. cross-compound, horizontal steam engine with condenser and air pump, and drives a differential waterworks pump. The apparatus is so arranged as to be available for a large variety of experiments, both on the steam and on the water ends.

The second of the machines included in the gift was the 220 h.p. quadruple-expansion marine engine located just beyond the machine just described, and represented in Fig. 10. It operates a direct-current dynamo and is intended for use in experiments on steam consumption, in thermodynamic investigations, particularly with reference to the use of superheated steam, and for experiments in governing.

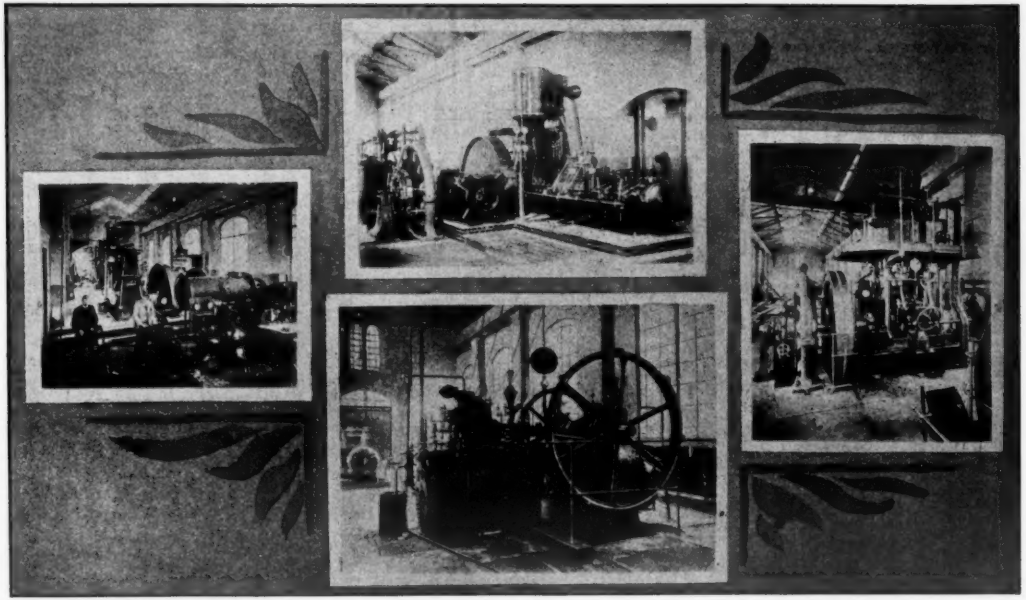


FIG. 11. Machine Laboratory, Triple Expansion Engine. FIG. 13. Machine Laboratory, Testing Stand.
FIG. 10. Machine Laboratory, Quadruple Expansion Marine Engine. FIG. 12. Machine Laboratory, Locomobile.

Beyond the marine engine is located a third machine, likewise included in the gift, a triple-expansion steam engine of 150 brake h.p. with an adjacent superheater (Fig. 11). It will be noted that the arrangement chosen was with particular reference to the use of the machine for laboratory as well as power-generating purposes. A dynamo generating current for general use in and about the plant is coupled to the main shaft, but between it and the prime mover is a crank and engine frame designed for the attachment of a compressor or blowing-engine cylinder or some other piece of experimental apparatus, in which case the generator may be uncoupled or allowed to run without excitation.

This machine is also intended for use in connection with thermodynamic investigations, particularly with reference to the conditions involved in the use of superheated steam. It is further arranged for use in connection with investigations of frictional losses at various points in the mechanism, and in connection with problems in regulation.

Another of the machines included in the steam equipment is the Wolf Locomobile (Fig. 12), presented to the laboratories by the manufacturers. This type of stationary machine, perhaps better known on the continent than in this country, is the result of attempts to produce an efficient self-contained element for small and medium powers and has attained a state of great perfection. The example here shown is of the compound-condensing type with internally fired boiler.

Of the remaining equipment of the laboratory it was unfortunately impossible to obtain any views. Among the more important of the apparatus included are a 300 k.w. Parsons turbine with generator, a 250 k.w. Curtis turbine also with generator, a 160 h.p. 4-cycle, single-acting, suction-gas engine with producer, a 60–75 h.p. Diesel engine and an SO_2 refrigerating machine. The above comprises the principal fixed apparatus of the laboratory. In addition there is a large amount of smaller apparatus which it is the policy of the management to set up on the testing-stand when being utilized for experimental purposes or for investigation and to remove

again as soon as possible and store away till wanted again. One of the objects of this system is to enable the students to obtain practice in the setting up of the apparatus used in the tests. A general view of the testing-stand is had in Fig. 13.

The instruction in the engineering laboratory is arranged in three courses—Eng. Lab. I, II and III. In the first course which covers one semester or term the instruction includes such elementary introductory work as the calibration and use of indicators, gage testing, the use and principle of the Orsat apparatus and the experimental determination of the heat value of solid and of liquid and gaseous fuels, by means of the Mahler bomb and the Junkers calorimeter, respectively.

The second course, two semesters in length, includes a systematic series of experiments on boilers, steam engines and turbines, pumps and compressors, condensers and combustion engines, together with investigations of steam-turbine nozzles, governors and other machinery.

The third course, likewise two semesters in length, is of a more advanced nature and is intended for those who take the option " experimental engineering " of the mechanical course, and for such of the older students in other options as are qualified for the work which it embraces. In this course, extended investigations are pursued with considerable attention to completeness and accuracy, both in the working out and in drawing conclusions. Some of the investigations include exhaustive tests on steam-turbine nozzles and on the steam-turbines themselves, and studies in regulation of prime movers.

The methods of instruction and of working up the tests in the first two cases, Engineering Laboratory I and II, are about as follows:

At the beginning of each exercise, the instructor gives an outline of the test to be performed, and an explanation and description of the apparatus used. He then goes over the apparatus itself with the group and makes sure that all understand the principle of its operation and the methods of taking readings. Then someone of the group volunteers or is selected

by the members to act as chief and under the direction of the instructor a log-sheet is prepared for recording of data and the leader assigns the members to the various posts. During the test the instructor simply reassures himself occasionally that same is proceeding normally; otherwise the entire responsibility is on the students. All who wish to work up the test make copies of the log-sheet at the close of the experiment; or one or two from the group volunteer to prepare the data. Each one works up his own report independently, emphasizing such phases of the investigation as interest him most, but guiding himself by a series of suggestions on the test blank which he receives in connection with the test. A copy of the blank form used may be found in the appendix. Each instructor is at liberty to use his own judgment in specifying what form the report shall take; and in correcting the students' work the practice is to look over the results only in a general way, and not to seek for absolute correctness in the numerical work by checking. In many cases where the computations are long and complicated it is customary for the instructor to meet the group and work out the test with them, calling for the numerical computations from various individuals as he goes along. This is done with the idea of saving time which would otherwise be spent by the student in futile efforts to worry through the matter by himself without any clear idea of what he is doing. All tests must however receive such corrections as may be called for before they are certified.

The success of the machine laboratory was the signal for the inception and completion of a whole series of correlated institutes in connection with the various courses represented in the program of the department of mechanical engineering. One of these is the laboratory of mechanical technology, located in the basement story of the extension (Fig. 1). In speaking of it here it may perhaps be permissible for the sake of clearness to emphasize the relation which this laboratory bears to student workshops in American technical schools. As has been emphasized in the reports which have been presented to the society by certain of its members who have visited and

inspected the German schools, one of the requirements for those students who wish to take examinations for the degree in mechanical engineering is that they must serve at least one year as special apprentices in a suitable factory or other industrial enterprise. Six months of this time must have been spent consecutively, and the remainder in periods of not less than two months each. All important departments of the works must be included, as for example, the foundry, the pattern shop, the machine shops and the erecting department. Frequently considerable time is spent at construction and installation in the field. Similar requirements exist in the departments of naval architecture and of mining.

In the education of the engineer in Germany and indeed in other European countries as well, the year of practical training and experience exercises a far-reaching and important influence on the whole course of study and on the scope and the methods of instruction in the engineering departments of the technical schools. It is almost superfluous to say that it enables the student more easily and better to understand and to appreciate all the professional instruction of the course. In this way it renders possible an abbreviation in the work of the instruction in many cases. The year in practice also gives the student an opportunity to find himself, to learn his own tastes and capabilities, and to estimate the opportunities that are open to him in the practice of the profession he has chosen. It therefore enables the work in the more advanced professional subjects to be more specialized, *i. e.*, to be more closely directed to the end in view. Since, too, the four-year course is relieved of shopwork, more time is rendered available for the professional studies of the course, and it is thus possible to lay the foundations of engineering education on very broad lines.

It may be interesting to note here a specific case which illustrates the attitude of the German educator with regard to the question of school workshops. In his report* on American

* See A. Riedler, "Amerikanische technische Lehranstalten," *Zeitschrift des Vereines deutscher Ingenieure*, 1894, Vol. 38, p. 405 et seq., from which paper the extracts are quoted.

Engineering Education, written shortly after his visit to the United States in 1893, Professor Riedler says, in speaking of the experience which has been made with them in Germany: "Shops for instruction do not belong *at all* in technical schools. In all technical schools where they have existed they have degenerated into trifling—into play-work. The instruction has everywhere been carried on as instruction in manual training, and has often been conducted by poor teachers, while just in this subject educational success demands excellent teachers. I cannot change my views in spite of the school shops in American engineering colleges, and notwithstanding the fact that these are suitably equipped and conducted." And later on in the same report he says: "In the American school workshops too, especially if the students first come in contact with practical work in the engineering school itself, nothing is achieved which is in proportion to the great expenditure of time. The time expended is still not sufficient to learn anything truly useful, if the practical sense of the student has not previously been developed." And in making his recommendations he says, when speaking of the introduction of American ideas and institutions into German schools: "We should introduce scientific laboratories for the development of the sense of observation and perception, and for the fostering of the spirit of research, as rapidly as possible, but the introduction of school shops, on the other hand, would be a mistake, a step backward, and a beginning without an object, for in the engineering school it is too late to try to inculcate practicalness. This the student must bring with him as a result of his previous training." It should be understood that the above has been quoted solely with the intention of attempting to make clear the German point of view and not as an adverse criticism of our own methods and institutions.

Mechanical technology is understood to treat of the means and methods by which the metallic raw materials are transformed into such finished products as are of prime importance to the designer of machinery; it includes as well, therefore, the subject of metallic raw materials. At Charlottenburg the

subject is treated from the point of view of a preliminary to the instruction in design.* The laboratory instruction is not offered as a substitute for the practical training of the student in the foundry and shop, which it is intended shall be obtained in the year of practical experience. It is rather intended as a systematic supplement to this preparation of the student on the practical side, which, it is admitted occurs in a relatively short time and often one-sidedly, perhaps without as much supervision or instruction as might be desirable. Therefore for the successful prosecution of the course a certain amount of preparation in the shop is indispensable, and the lack of it is felt to constitute a hindrance to the student in his work in mechanical technology.

The work in the laboratories includes: Exercises in sketching the moulds with descriptions of the methods of founding of the more common machine elements; similar exercises in connection with forging; studies in the methods of operation and characteristics of various machine tools; experiments in the determination of the cutting speeds and feeds for different materials and machine tools; of the efficiency of such tools, of allowable and ultimate tool pressures; determinations of the power required in operations involving pressing and drawing.

In connection with the course in mechanics, laboratory work is given in statics, dynamics, friction and strength of materials. The laboratory of strength of materials, where this instruction is given, is located in the building formerly occupied by the government station for testing of materials (Fig. 1). Experiments are performed to illustrate the important principles of the subject, and embrace such exercises as: determinations of coefficient of friction, especially for lubricants; experiments on pendulum governors to familiarize the student with the

* For a very complete description of the scope and subject-matter of this course see E. Heyn, "Der technologische Unterricht als Vorstufe für die Ausbildung des Konstrukteurs," *Zeitschrift des Vereines deutscher Ingenieure*, 1911, Vol. 55, p. 201.

dynamical principles involved; tests of metals in tension, compression, bending and torsion.

At Charlottenburg and indeed in most European schools the instruction in hydraulic motors forms a part of the work of the mechanical engineering course. The testing station for hydraulic motors is therefore under the control of this department and serves as an adjunct to the work in design.

At the time that the mechanical laboratory, already referred to, was originally projected, it was expected that it would be capable of comprehending all types of machines which are usually dealt with in the course of the instruction in a technical school. In accordance with this idea the laboratory in-

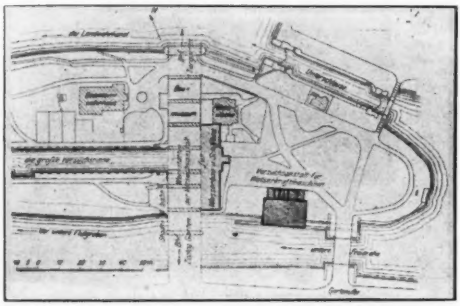


FIG. 14. Testing Station for Hydraulic Motors, Site.

struction originally included experiments on a Pelton wheel and on a centrifugal pump. The necessity for a more extensive treatment however, and the presence in the Landwehr Canal, which passes the easterly end of the school grounds, of an available water power approximating 50–60 h.p. under a head of 5 or 6 feet, and with a flow of anywhere from 10 to 20 cubic feet per second, led to the establishment of the present station.

A plan of the site is shown in Fig. 14.* The canal divides to

* From E. Reichel, "Die Versuchsanstalt für Wasserkraftmaschinen an der Königlichen Technischen Hochschule zu Berlin." Reprint from

pass to either side of a small natural island. One branch is utilized for locks and the other serves as a waste-way; it is on that side of the island nearest to the waste-way that the station is located. It may be noted in passing that the island also serves to accommodate the experiment station for hydraulics and naval architecture, with its huge experiment basin.

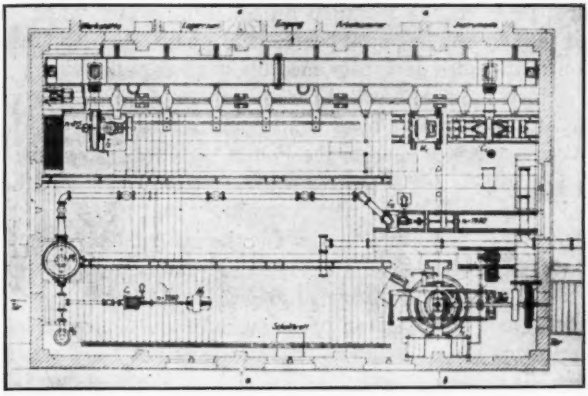
An exterior view of the testing station for hydraulic motors is shown in Fig. 15. The simplicity and lack of any attempt at architectural effects are apparent. The machine hall (Fig.

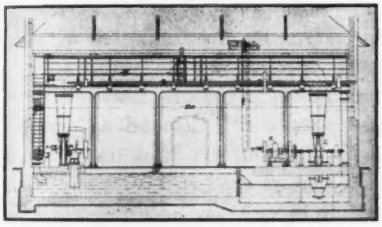
FIG. 15. Testing Station for Hydraulic Motors, Exterior.

16*a*) of the station contains a wheel pit for the installation of vertical shaft penstock turbines, a 20 h.p. enclosed turbine with scroll casing, a low pressure and a high pressure centrifugal pump, and a testing stand for Pelton wheels.

In the first of these, the wheel-pit, T_1, is so arranged as to take Francis wheels of various diameters and is located at the end of the head race; the tail race is in direct prolongation of the latter. The equipment provides for the conversion of the power developed into electrical energy in a generator which is coupled to the vertical shaft by means of bevel gears, or for its absorption and measurement by means of a specially designed sensitive brake which is mounted directly on the vertical shaft of the turbine. This pit is used largely for experi-

Festschrift zum Fünfzigjährigen Bestehen des Vereins deutscher Ingenieure—from which the other cuts were also taken.





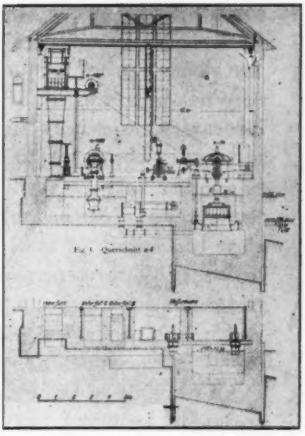


FIG. 16, *a*, *b*, *c*. Testing Station for Hydraulic Motors, Plan and Sections.

mental tests for Francis wheels for outside parties, and in connection with scientific experiments on various types and designs. It serves in connection with the instruction as an example of a low-head installation.

The enclosed turbine, T_2, also of Francis type, is fed from

a steel plate trough mounted on brackets; water being supplied to it by the low-head centrifugal pump, C_1. The installation is intended to typify medium-head installations.

For high pressure work the water is pumped to a large steel tank, W_1, by the high-head centrifugal pump, C_2, from which it may be taken to operate the Pelton turbines. The installation is available for pressures equivalent to a maximum head of 650 feet.

The power necessary to operate the centrifugal pumps in both cases is taken from the municipal mains in the form of electrical energy and converted by means of motors.

The instruction is given by means of a systematic series of experiments which embraces brake tests of low-, medium- and high-head turbines, investigations of low- and high-head centrifugal pumps, determinations of water volumes and pressures by various methods and of the available head at the station with an engineer's level. One feature connected with the laboratory work appeals very strongly to the writer and may not be unworthy of comment. It is the practice in this laboratory, especially in those tests which demand a large number of observers, to transfer the students from one post to another between readings, so that at the conclusion of the test every student has taken readings at every post and has a clear conception of the test as a whole. This system renders necessary the presence of several assistants in addition to the instructor in charge, but in the case in question has proved well worth while. Copies of the blank form used may be found in the appendix.

An example of the plan which is being followed frequently to-day in technical institutions of separating those portions of laboratories which serve purely for purposes of instruction in the principles of any one of the applied sciences from those portions which are devoted to advanced work in the same branch, and which therefore include examples of the latest applications, installations on a practical scale, and facilities for original investigations and research, is afforded in the

electrical engineering experiment station.* This laboratory is intended in this sense as a supplement to the electrical laboratory already referred to; while not mechanical engineering laboratories, both have been mentioned here because the instruction in electrical engineering is given as an option in the mechanical engineering course and they therefore form part

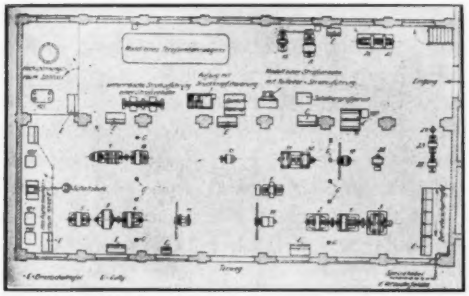


FIG. 17. Electrical Engineering Experiment Station, Plan of Machine Room.

of the equipment of that department. This laboratory is installed in a building at the point shown in Fig. 1. A plan of the machinery hall is given in Fig. 17.† The equipment is

* For a fuller description of this laboratory see W. Reichel and M. Gerstmeyer, "Das Elektrotechnische Versuchsfeld der Technischen Hochschule zu Berlin," *Zeitschrift des Vereines deutscher Ingenieure*, Vol. 51, p. 2129 et seq., from which the views are taken.

† The laboratory contains the following apparatus: direct current motor, coupled with a direct current generator and a polyphase generator; direct current generator, coupled with a direct current generator; rotary converter; direct current generator; polyphase generator, coupled with a direct current generator; direct current generator, belted to a direct current generator; polyphase induction motor; direct current railway motor; commutator motor for single phase alternating current; crane motor for single phase alternating current; three phase induction motor; direct current motor, coupled with a charging generator and an exciter; direct current generator, coupled with a high-tension machine; direct current generator, coupled with a three phase alternator and polyphase transformers.

large and varied; most of the machines are 100–150 k.w. capacity. A large storage battery with a capacity of 1,200 ampere hours is located in the basement of the head house. The transformer-room, arranged for 10,000 v., is separated from the main hall by a wire fence. The high tension stand equipped for the production of voltages as high as 200,000 is similarly separated from the main hall. A view of the main portion of the hall is afforded by Fig. 18, and views of the transformer room and the high tension stand in Fig. 19 and Fig. 20 respectively.

The instruction comprises two series of experiments, arranged with reference to the needs of the mechanical and electrical students respectively. It is a distinctive feature of the instruction for the mechanical students that all tests are so arranged that the reports on them may be completed during the exercise under the direction of the assistant and must be handed in to him at the close of same to receive credit. In the appendix copies of several of the blank forms used as guides will be found.

To understand the reason for the extent and scope of three of the remaining institutes which are connected with the school it is important to bear in mind, *first,* that in Germany the higher institutions are without exception government institutions and that consequently as such one of their functions is to serve the state by providing technical education for those entering such branches of the civil service as of necessity demand technical training on the part of these individuals; *second,* that as such all their departments and institutes are planned not only as educational factors but as possible factors in the development of the national industries. Furthermore, it is the fixed and definite principle of the government to grant to the men who give instruction in the institutions of learning every opportunity to develop themselves in their professions and to contribute materially through their efforts to the present knowledge in their various fields of activity.

The three institutions alluded to are: the laboratory for combustion motors, the experiment station for elements of

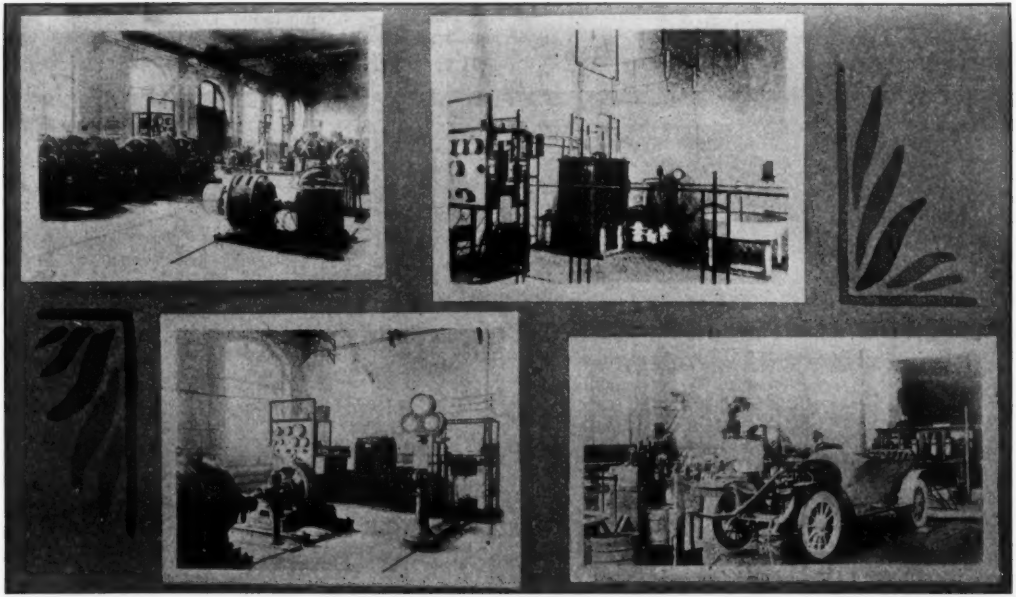


FIG. 18. Electrical Engineering Experiment Station, Interior. FIG. 20. Electrical Engineering Experiment Station, High Tension Stand. FIG. 19. Electrical Engineering Experiment Station, Transformer Room. FIG. 21. **Laboratory for Combustion Motors, 100 H. P.** Benz Automobile, front view.

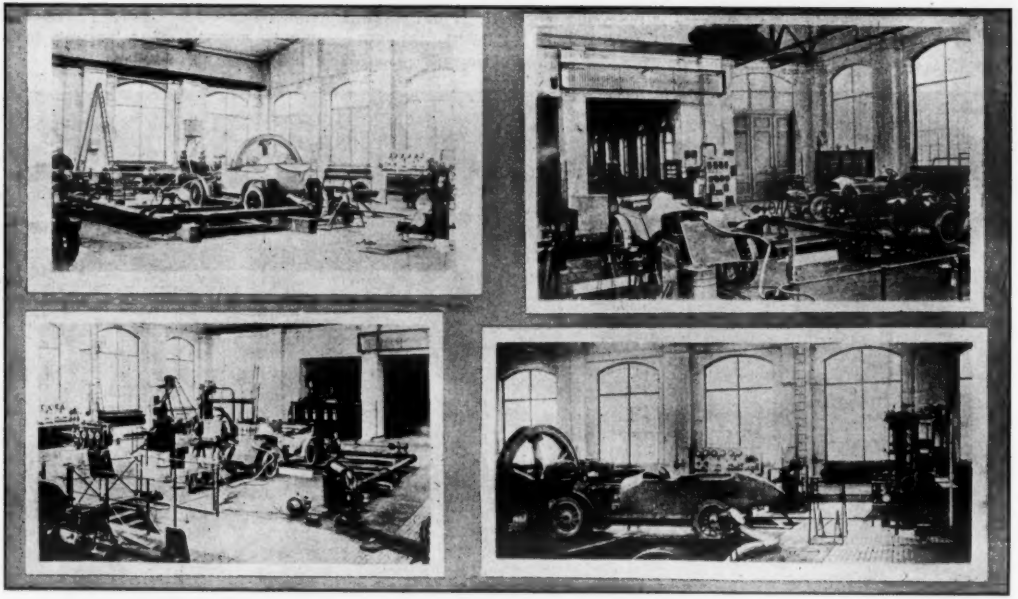


FIG. 25. Laboratory for Combustion Motors, 75 H. P. Adler Automobile, rear view. FIG. 23. Laboratory for Combustion Motors, 75 H. P. Adler Automobile, front view. FIG. 24. Laboratory for Combustion Motors, 75 H. P. Adler Automobile, side view. FIG. 22. Laboratory for Combustion Motors, 100 H. P. Benz Automobile, side view.

machine design, and the experiment station for machine tools (Fig. 1). These three laboratories are at the present time solely for the use of the instructing staff of the design courses in the respective subjects. They are being developed by that body, however, with the intention of ultimately providing for instruction or research on the part of more mature students enrolled in the correlated courses.

Perhaps a few views, taken from cuts illustrating the recent report* of the first of these, will indicate what line of work is being pursued. Fig. 21 shows a front view of a 100 h.p. Benz automobile on the testing stand; Fig. 22 a side view of the same. Fig. 23 shows a front view of a 75 h.p. Adler automobile on the same stand; Fig. 24 gives a side view and Fig. 25 a rear view of the same machine.

The experiment station for machine tools† was founded in 1904, at the same time as the regular professorship in that subject, and was the first research laboratory of the kind in Germany.

Figs 26*a* and 26*b*‡ are the plans of the first story and basement respectively. The first story contains the machine room, a grinding room and several smaller rooms for the use of the chief engineer, the assistants and the workmen; the basement, an insulated chamber for fine measurements, a forging and

* See A. Riedler, "Wissenschaftliche Automobil-Wertung. Berichte I–V des Laboratoriums für Kraftfahrzeuge an der Königlichen Technischen Hochschule zu Berlin," R. Oldenbourg, Berlin & Münich, from which the views are taken.

† See G. Schlesinger, "Das Versuchsfeld für Werkzeugmaschinen an der Technischen Hochschule zu Berlin," *Zeitschrift des Vereines deutscher Ingenieure*, 1912, Vol. 56, p. 857 et seq., from which the views are taken.

‡ The laboratory contains the following apparatus: large and small experimental lathe; large and small experimental boring machine; horizontal shaping machine; hand drilling machine; experiment stand for welding apparatus; compressed air gauge tank; testing stand for air hammers; instrument case; switch-boards; tool and cutter grinders; compressor coupled with motor; air filter; automatic rheostat; electrical hardening furnace; gas hardening furnace; gas forge; high pressure blower; forge; anvil; ventilating fan; saw; electric welders.

hardening equipment, an electric welding apparatus and a compressed air plant. A view of the interior of the machine room is had in Fig. 27.

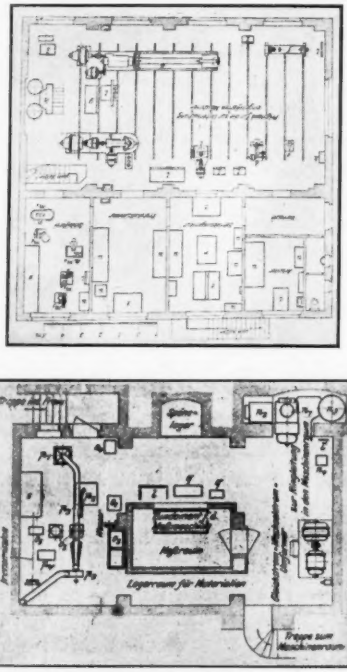


FIG. 26*a*, *b*. Experiment Station for Machine Tools, First Story and Basement.

We have to consider lastly the government station for the testing of materials. These laboratories were established in their present scope in 1883; while not under the direct control of the department of mechanical engineering, they provide instruction for students of that department, and form one of the institutes of the school as a whole.

The original quarters on the school grounds having become

inadequate, the station was removed in 1904 to Gross-Lichterfelde, a suburb of Berlin. A view of the new plant* is had in Fig. 28. It comprises six subdivisions:

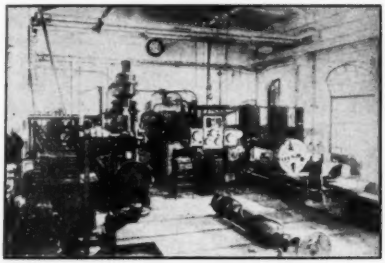


FIG. 27. Experiment Station for Machine Tools, Interior.

Division I for Tests of Metals,
Division II for Tests of Building Materials,
Division III for Tests of Paper,

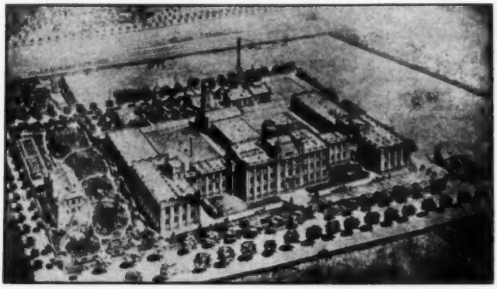
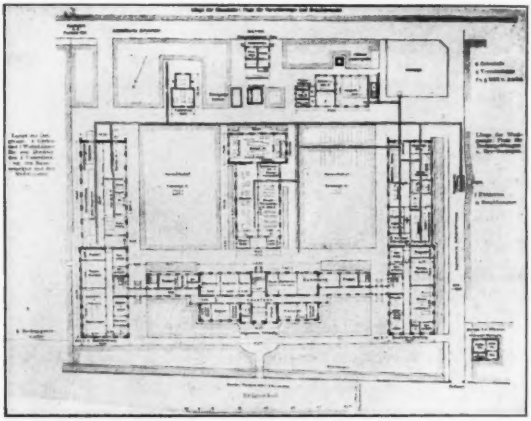


FIG. 28. Station for Testing of Materials, General View.

Division IV for Metallography,
Division V for General Chemistry,
Division VI for Tests of Oils.

* See Martens and Guth, "Das Königliche Materialprüfungsamt der Technischen Hochschule Berlin auf dem Gelände der Domäne Dahlem beim Bahnhof Grosslichterfelde West," Julius Springer, Berlin, 1904.



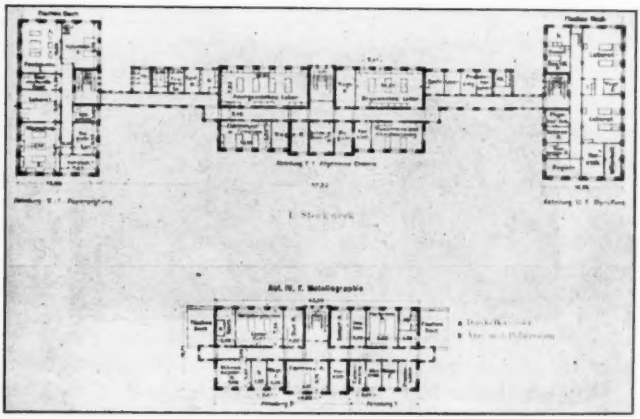


FIG. 29*a*, *b*. Station for Testing of Materials. Plan of first and second stories.

A general ground-plan indicates more clearly (Figs. 29*a* and *b*) the disposition and occupancy of the structures.

The courses in testing of materials embrace a series of exercises in all of the above departments, but principally in the division for tests of metals. They are intended especially for those students who elect to take the option "experimental engineering" of the mechanical course.

The writer has endeavored in the above brief and incomplete sketch to give a general idea of a portion of the laboratory equipment of the Charlottenburg school. In discussing the main features of this equipment, the aim has been to show as clearly as possible in what manner and with what modifications, if any, the Germans have applied the ideas obtained from their colaborers in the educational field on this side of the Atlantic.

Appendix.

In the following the writer has endeavored to reproduce the principal portions of the material contained in one or two specimen log sheets or reports as used in the respective laboratories, together with a brief note as to the form of sheet adopted. No responsibility is assumed for correctness of translation or accuracy of data contained in same.

Examples 1 and 2 are based on reports used in the Machine or Engineering Laboratory. Double sheets, $8\frac{1}{4}'' \times 13\frac{1}{4}''$, are used, on the third and fourth pages of which the data here reproduced is printed, the first page serving as a title page and the whole as an envelope for such sheets as the student uses in working out the test.

Example 1.

Exercises II. Experiment 23.

Surface Condensation.

(1) Type and dimensions of condenser and of wet and dry air-pump.

(2) Test of the system with constant supply of cooling water.

Variation of the steam consumption by variation of load on the prime mover.

Measurements:

Quantity of steam, kg./hr.

Quantity of cooling water, kg./hr.

Abs. pressure in condenser, at. abs. (vacuum in per cent. of atmospheric press.).

Temperatures, °C. steam (entrance).

Temperatures, °C. steam (exit).

Temperatures, °C. condensed steam.

Temperatures, °C. cooling water (ent.).

Temperatures, °C. cooling water (exit).

Dynamic resistance of condenser, mm. Hg.

Computation of results:

Determination of steam temperature from pressure in condenser.

Specific cooling water consumption.

Specific cooling water consumption of the ideal condenser.

Increased consumption over ideal condenser.

Heat extracted by condenser per hour.

Heat content per kg. of entering steam (moisture; superheat).

Velocity of cooling water.

Heat transfer coefficients.

Partial pressures at exit of condenser.

Resistance of the condenser in m. of water.

Example 2.

Exercises II. **Experiment 43.**

Investigation of a Governor and of the Regulation of a Lighting Machine.

(1) Investigation of the properties of the governor when disconnected from the valve gear.

(*a*) Determination of the energy E of the governor by weighing ($E =$ constant for all positions of the collar in the case of the Kley governor on the Görlitz engine).

(*b*) Determination of the uniformity d by recording the rotative speed and the corresponding positions of the collar by means of the Horn tachograph for both rising and falling collar. The values are to be recorded graphically, the values of the rotative speed as abscissæ, the collar positions as ordinates.

(*c*) Calculation of the sensitiveness, which depends upon the friction E_r, from the values obtained under (*b*), which represent the maximum and minimum rotative speeds for the several collar positions.

$$E_r = \frac{n_1 - n_2}{\frac{n_1 + n_2}{2}}.$$

The table of recorded results will contain:

Travel of pencil h_1	Collar travel $h = 2.04h_1$	n_1	n_2	$E_r = \frac{n_1 - n_2}{\frac{n_1 + n_2}{2}}$

(*d*) Numerical proof of the value of the energy and the uniformity from the dimensions given. Determination of the *C*-curves; recording of the values in the sketch. (Velocity ratio between governor spindle and valve gear shaft: 4/3.)

(2) Investigation of the action of regulation, taking into account the influence of the valve gear and the receiver.

(*a*) Properties of the valve gear: reaction. Settings for various turning moments, *i. e.*, the variation of these with the position of the collar. Graphical representation of this.

(Form of table to be used in recording the results; sketch.)

(*b*) Taking of regulation diagrams for complete changes and for partial changes in the load with the Horn tachograph. Interpretation of these. In particular the following are to be ascertained:

(α) The maximum variation in speed (sub-division of this into its three causes: static properties of the governor, inertia of the governor masses, receiver).

(β) Duration of the regulating action (till the variation in the rotative speed is smaller than 2 per cent.).

(Diagrammatic sketch of governor mechanism with dimensions and other necessary data.)

Examples 3 and 4 are based on reports used in the Electrical Engineering Experiment station. Single or double sheets are used as occasion requires, measuring $8\frac{1}{4}'' \times 13\frac{1}{4}''$; the data here reproduced, together with the spaces indicated for the recording of readings or observations, occupy the available space from the first page on, exclusive of heading. The whole serves as an envelope for any sheets bearing plots or curves which form part of the report. It may again be emphasized that this type of report is intended for use where results are worked up during the test and reports are called in at conclusion of same.

Example 3.

Wiring and Operation of a Direct-current Machine.

Diagram of wiring:

(Space)

Operation of the direct current machine: State what must be done in each case and give reasons.

Operation as motor.

Starting:

(Space)

Regulation and variation of speed:

(Space)

Shutting down:

(Space)

Operation as generator.

Bringing up to pressure:

(Space)

Operation in parallel; throwing in:

(Space)

Operation in parallel; loading:

(Space)

Shutting down:

(Space)

Note: In performing this experiment, the machine was operated in accordance with above program; then report was prepared, using blank spaces for answers.

Example 4.

Testing of Air Line Insulators.

The operating voltage of an air line insulator is determined as a fraction of that voltage (safety factor) which the insulator will stand on the testing apparatus under an artificial rain of an intensity equivalent to that occurring in nature (about 2–5 mm. per min.), without permitting spark discharges to jump across from its edge.

The insulators to be tested up to this voltage at which edge discharge occurs were attached by their support to one pole of an alternating current high tension transformer, with a wire loop about their groove to the other pole.

The testing of all insulators took place at first dry, then in the rain. The voltage was gradually increased till passage of sparks occurred by varying a water resistance in the low tension circuit.

Wiring diagram of apparatus:

(Space for sketch of wiring.)

Results of the Tests.

(Tables for recording the measurements, weight, voltages, humidity, intensity of rainfall, etc.)

Sketch of an air line insulator (for mechanical engineers) with value of the operating voltage in case of polyphase current.

(Space for sketch of insulator with dimensions and rating.)

Example 5 is taken from the forms of report blank used in the Experiment Station for Hydraulic Motors. Here, too, double sheets, $8\frac{1}{4}'' \times 13\frac{1}{4}''$, are used, on the first and fourth pages of which the data given below, for example, is printed, the first page also serving as a title page and the whole as an envelope for such sheets and plots as may bear the numerical work or curves of the report.

Example 5.

Exercise No. (—). Experiment Station for Hydraulic Motors.

Brake Test of a Francis Scroll Turbine at Constant Gate Opening.

(Setting on the scale of gate-opening, $a =$).

The following observations are to be made:

(1) The head H by means of floats in the head and tail races.

(2) The quantity of water Q by means of a weir in the tail race.

(3) The force P at the end of the brake beam L by means of scales.

(4) The rotative speed n by a counter.

The following calculations are to be made:

(5) The indicated horsepower N_i.

(6) The effective horsepower N_e.

(7) The efficiency E.

(8) Conversion of Q, P, n, N_i, N_e, to $H_1 = 1$ m.

The results obtained for Q_1, P_1, N_{e_1} and E are to be plotted as functions of n_1.

(Sketch of desired plot.)

(1) Determination of the head H. The float in the head race permits a direct reading of the height H_o of the head water; the float in the tail race is first to be set at the height of the weir edge; the reading on the scale $= c$. Then:

$$h = a - c,$$
$$H_u = H' + h = (H' - c) + a,$$
$$H = H_o - H_u.$$

(Sketch of apparatus with dimensions.)

(2) Determination of the quantity Q according to Freese's method:

$$Q = \tfrac{2}{3}(uBh)\sqrt{2gh},$$

in which:

$$u = (0.615 + 0.0021/h)(1 + 0.55(h/T)^2).$$

(Sketch of weir with dimensions.)

(6) Determination of the effective horsepower N_e.

The scales should be put in adjustment. From the values of the brake arm ($L = 0.798$ m.), the brake pressure P and the rotative speed n we have:

$$N_e = \frac{PL2\pi n}{60 \times 75} = \frac{Pn}{\frac{60 \times 75}{2\pi L}} = \frac{Pn}{897}.$$

(8) Conversion of Q, P, etc., to $H_1 = 1$ m.

$$Q_1 = \frac{Q}{\sqrt{H}}, \quad P_1 = \frac{P}{H}, \quad n_1 = \frac{n}{\sqrt{H}}, \quad N_{i_1} = \frac{N_i}{H\sqrt{H}},$$

$$N_{e_1} = \frac{N_e}{H\sqrt{H}}, \quad E = \frac{N_e}{N_i} = \frac{N_{e_1}}{N_{i_1}},$$

$$N_i\,(\text{H.P.}) = \frac{1000}{75}\, Q\,(\text{cbm.})\, H\,(\text{m.})$$

(Sketch of brake and scales with dimensions.)

(Table with headings for recording readings and calculated results.)